MARCH 8, 1956
EVERY OTHER THURSDAY

MACHINE DESIGN

A PENTON PUBLICATION

FUSES

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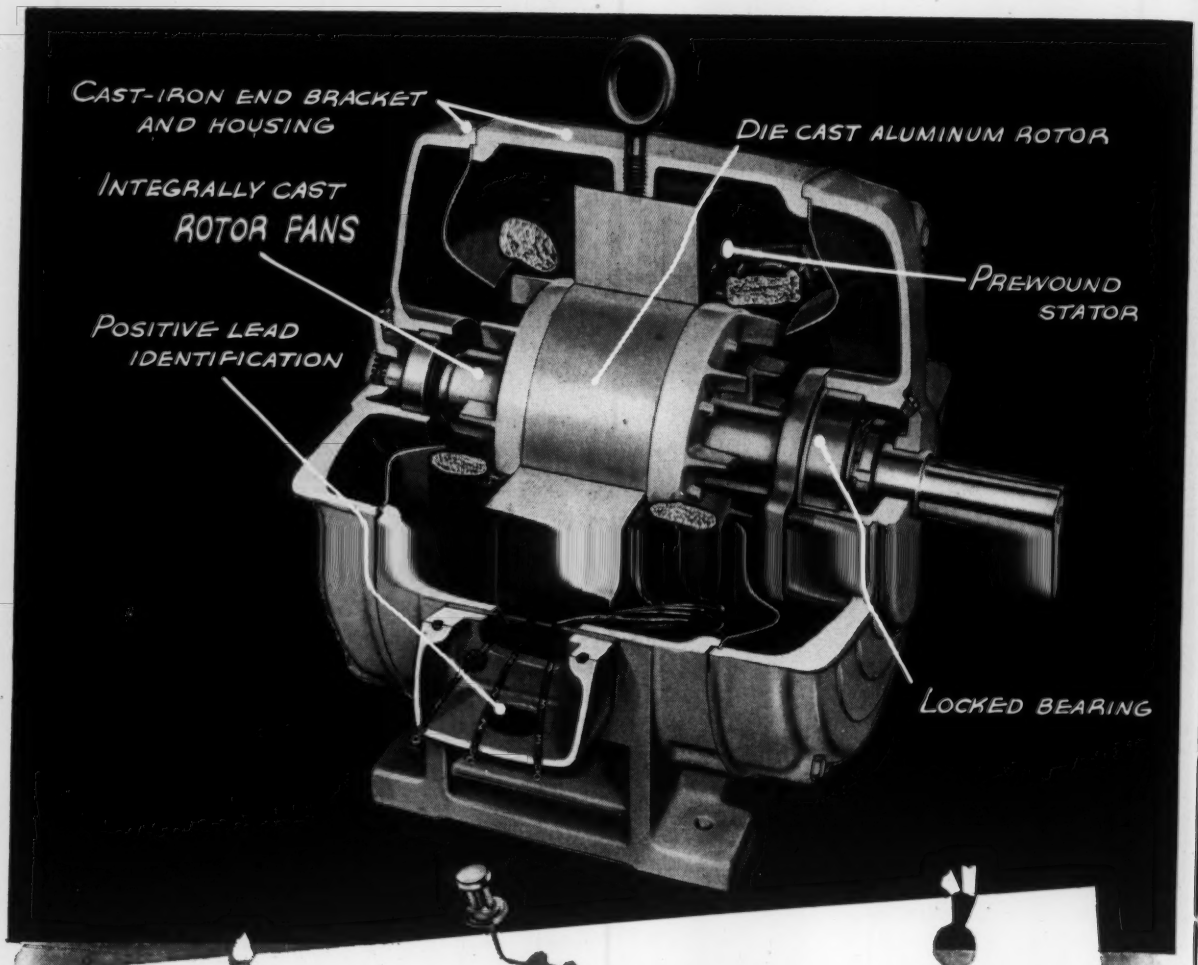


Are you getting all these extras in the motors you buy?

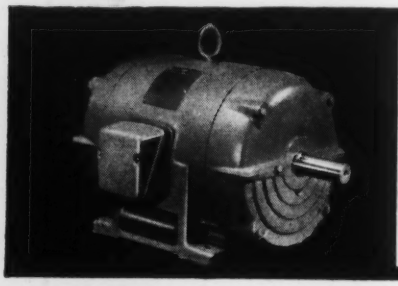
Louis Allis gives them to you, because they build their standard motors with special care

For years, Louis Allis has specialized in special motors for many of industry's toughest drive problems. Such installations call for extreme care in both motor design and manufacture—care that has become a habit with us. That's why we build our standard motors with special care.

What does this mean to you? It means that you get a motor with extra features —a motor that runs better, lasts longer. Here are a few of the extra reasons why:

- New exclusive phenolic impregnating varnish provides high thermal and chemical resistance. It remains resilient and resists aging for longer motor life.
- Locked bearings, inner race to shaft, outer race to end bracket, reduce end play and increase bearing life.
- Increased protection not only for the motor, but also for operating personnel. Double end ventilation permits maximum end bracket enclosure—prevents foreign matter from entering motor.
- Quiet operation obtained by careful design and test. Close manufacturing tolerances assure perfect alignment and minimum electrical noise.

There are many other features such as cast iron construction, positive lead identification, split conduit box—but our new bulletin No. 1700 describes all the many extras you get in a Louis Allis standard motor. Write for your copy.



A complete line of standard rerated motors in frames 182 through 326U now in stock. Special rerated motors are available on short delivery.

LA-108

THE LOUIS ALLIS CO.
MILWAUKEE 7, WISCONSIN

—ITEM 151—
For More Information Circle Item Number on Yellow Card—page 19

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Introducing the COMET II

An Advanced Conception of Valving by Ross!

- Direct solenoid operated, balanced spool 4-Way—for air or oil service.
- Engineered and built to tolerances of .0001".
- Conforms to JIC standards.
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Write, wire or phone for complete information

Control

See the New Comet II at the ASTE Show, Booth 696.

Ross OPERATING VALVE COMPANY

109 E. GOLDEN GATE AVENUE • DETROIT 3 • MICHIGAN

Now-they fight fire with steel

BURNING problem for engineers of a large, fire-fighting-equipment manufacturer was the compact V-belt drive on their high-pressure, water-pumping units. Standard belts sometimes failed at the height of the first fire they fought.

Since failure at a fire couldn't be risked, the G.T.M. – Goodyear Technical Man – was consulted. He specified matched sets of COMPASS-V-Steel Belts, sinewed with airplane-type steel cables to handle the heavy loads without a slip. And they do.

Firemen report these precision-built belts operate two to three years *without a single take-up*. Perhaps they can do the same for you. Find out by seeing the G.T.M., your Goodyear Distributor or writing Goodyear, Industrial Products Division, Akron 16, Ohio or Lincoln, Nebraska.

YOUR GOODYEAR DISTRIBUTOR *can quickly supply you with Hose, Flat Belts, V-Belts, Packing or Rolls. Look for him in the yellow pages of your Telephone Directory under "Rubber Products" or "Rubber Goods."*

COMPASS-V-STEEL BELTS by

Compass—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

GOODYEAR

THE GREATEST NAME IN RUBBER

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THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

March 8, 1956
Volume 28—No. 5

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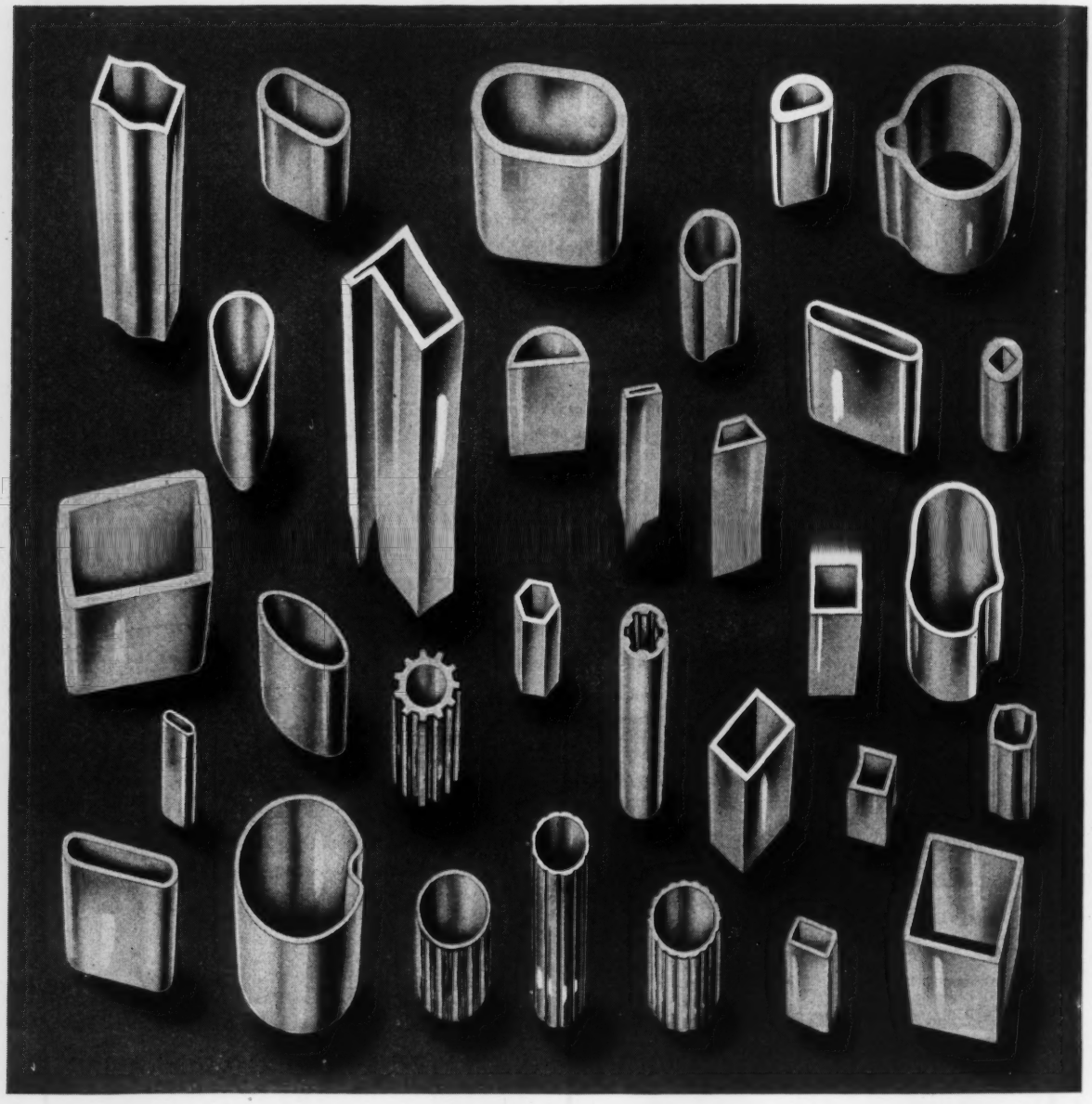

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Our specialized facilities and stock tools can save you time and money

Special-shape seamless tubes in straight lengths, or cut into short pieces, can save several steps in arriving at a finished product—can save you material and many direct labor costs. The American Brass Company's French Small Tube Division has turned out thousands of tubes in special shapes up to ¾" O.D. A variety of stock tools is available to save fitting-up charges.

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For action: See your American Brass Company representative or send in a sample, drawing, or description, together with the quantity you need, the metal, and other pertinent data. Address: The American Brass Company, French Small Tube Division, Waterbury 20, Conn. 5588

ANACONDA®

SPECIAL-SHAPE TUBES

Engineering News Roundup

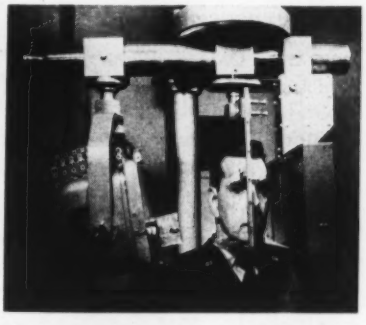
X-Ray Goes Wide-Screen

New Machine Takes Group Shots

WASHINGTON—An X-ray machine that rapidly takes a single picture of all the teeth in the dental arch has been produced by the National Bureau of Standards. Developed in cooperation with the Air Force, the panoramic X-ray machine should be useful in making full-mouth dental surveys of personnel on entering and leaving military service. Present techniques require up to 14 small films for a full mouth survey. Principles of the new device can be applied to radiography of other parts of the body as well.

In the NBS machine, the film is placed outside the patient's mouth and is exposed by passing a narrow beam of X-rays through his head from the rear. The picture of the teeth and associated structures is obtained on a single 5 x 10-in. film in about 40 seconds.

An X-ray source and film holding device follow semicircular paths on opposite sides of the patient's head. Movement of source and film is coordinated so that only those structures of the dental arch desired in the finished film are sharply projected.



MILITARY AIR-FREIGHTER: This is the first production model C-133A cargo craft completed recently by Douglas Aircraft. The plane's wing span is 179 ft. 8 in.; its fuselage is over 148 ft long and more than 16 ft wide. Gross weight is 255,000 lb. Four Pratt-Whitney T34-P-3 turboprop engines, each rated at 6,000 hp., drive 18 ft propellers. A crew of four can handle the plane. In its 90-ft long cabin the freighter can haul two 40,000 lb prime movers, 16 loaded jeeps or 20 jet engines. The plane could carry 200 troops

Train-X Has Own Central Station

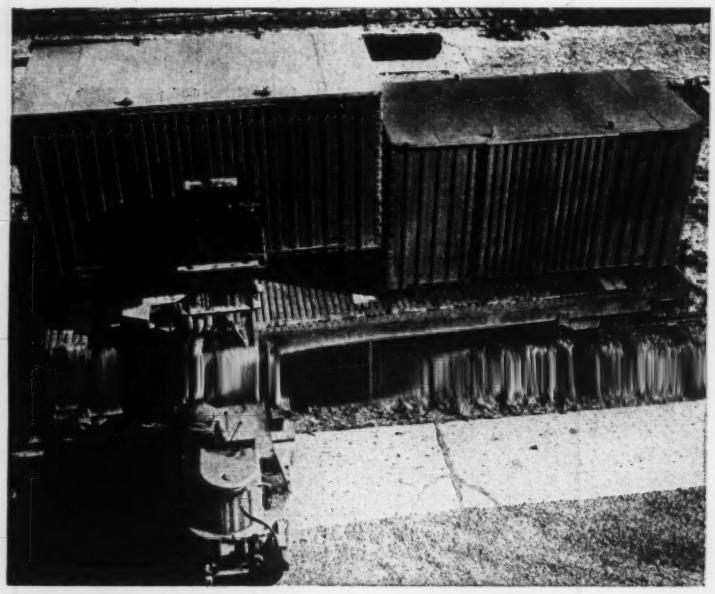
NEW YORK—The high-speed passenger carrier now being built for the New York Central Railroad features lightweight electrical equipment. A central electric power source will operate the train's lighting system and air conditioning and heating system instead of conventional axle-driven generators or individual diesel-driven generators and batteries. Power at 440 volts is to be distributed by an overhead trainline. According to a spokesman of the Pullman-Standard Car Mfg. Co., electrical equipment on the five-car Train X will weigh 15,000 lb in contrast to 67,200 lb on a conventional six-car coach train.

Fine Detail Reproduced on Stainless

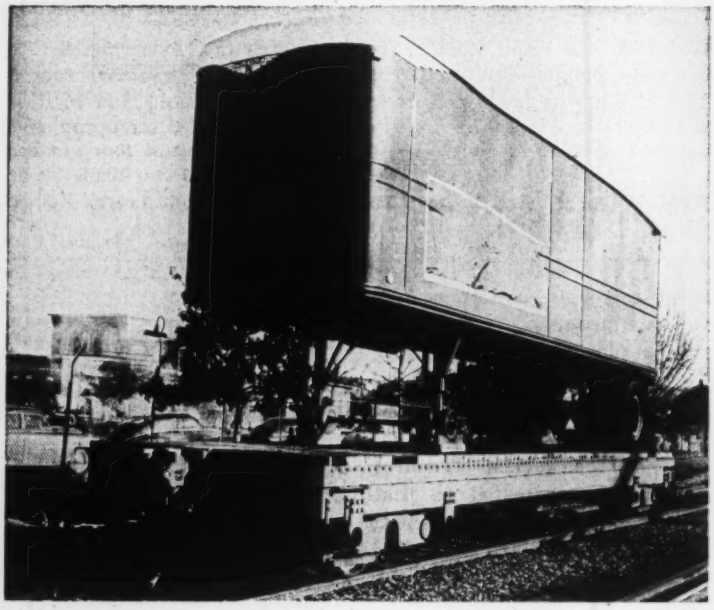
Photo Process Makes Permanent Markings

BOSTON — Development of a new process for permanently coating and marking the surface of stainless steel has been announced by Ateenate Inc. The process uses photo-chemical technique. It produces a hard, highly-ductile, non-crystalline surface which is said to be resistant to chemical and physical damage. The markings and coatings become an integral part of the metal because the process alters the chemical composition of the steel. It is effective on metals with a minimum chromium content of 11 per cent.

Ateenate claims the coating increases the strength of the metal,



VERSATILE FREIGHT CAR, named Adapto, has been developed by American Car and Foundry Div. of ACF Industries Inc. Basic car is 35 ft long, weighs 23,000 lb, carries 70,000 lb, has four wheels, fixed axles, air-cushioned suspension, rubber draft gear and roller bearings. Interchangeable superstructures convert basic Adapto into box car (above), "piggy-back" transporter (below), gondola, tanker, hopper, and even caboose



provides a smooth surface and may decrease the incidence of metal fatigue.

The coating is impervious to heat up to 1700 F and resistant to acids, alkalis and abrasives. It is claimed to have more resistance to wear and corrosion than stainless steel itself. Further, it is said the coating will not chip, flake off or peel, and the steel may be twisted, formed or bent without damage to the coating.

In reproducing detail, lines as fine as 0.001-in. can be readily obtained without distortion. Scales with 200 legible lines per in. have been reproduced with a tolerance of 0.002-in. over a total length of 17 in. The process can also reproduce half-tone photographs on stainless steel up to 150 line screen.

Pushbutton Operation Seen for Homes

AIEE President Predicts Centralized Gadget Control

NEW YORK — In the foreseeable future, operation of a house full of electrical appliances and devices may be controlled from one small room containing scores of electrical instruments and switches. According to Morris D. Hooven, president of the American Institute of Electrical Engineers, the home of tomorrow will contain solar batteries; heat pumps; weather conditioning; skillful illumination, refrigeration and cooling devices; and various labor-saving and chore-doing equipment, as well as numerous gadgets which will provide comfort and entertainment.

In a speech presented at the winter meeting of the AIEE, Mr. Hooven indicated that a whole day's activities could be set up on a recording tape in the control room. Services performed by means of preset pushbuttons can include rousing the member of the household, presenting their breakfasts and morning news at a specific time, and putting the cat out at night.

Plant Expansions

BURBANK, CALIF.—Plans for construction of a series of research laboratories on a 22-acre site at Stanford University, for advanced scientific studies in the realm of missiles and unmanned aircraft, were disclosed recently in a joint announcement by Lockheed Aircraft Corp. and the university.

LOS ANGELES—IBM has announced a multimillion dollar expansion of

Front Cover

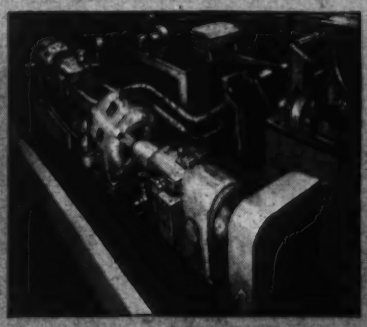
A glowing fuse may be a sign of trouble but it also provides a striking subject for the artistry of George Farnsworth's brush on this issue's cover. To shed more light on these important electric-circuit protection devices, see John C. Lebens' excellent article on fuses.

Facing Page—ITEM 157→

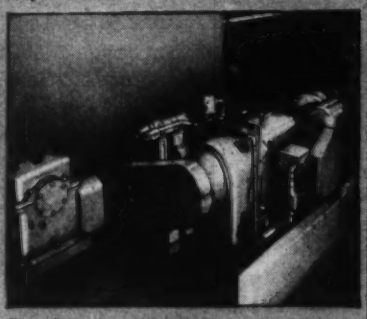
OILGEAR FLUID POWER DRIVES

"Stalpeth" machines add moisture barriers to telephone cable

These machines receive cable core, wrap it in aluminum and steel, solder the seam and coil it on reels. Oilgear *ANY-SPEED* Fluid Power Drives are an easy and economical means of synchronizing many machine units without a long lineshaft.



These Oilgear *ANY-SPEED* units drive the aluminum and steel corrugator units in perfect unison with the governing capstan unit.



The Oilgear *ANY-SPEED* capstan drive. Not shown here is another Oilgear unit driving the cable winding reels.

Solving the problem of close synchronization of driven members

As machines become more and more complex, combining more and more functions into a single unit, the problem of driving these machines successfully becomes more difficult.

This problem confronted Western Electric Company engineers in designing what they call their "Stalpeth" machines, two of which are shown above. These machines combine corrugating of steel and aluminum strips, forming them around the cable core, soldering the seam and then winding the assembly on reels at the far end. All of the members of the machine must be synchronized to the speed of the capstan unit. Going by their experience with other somewhat similar machines, Western Electric engineers again turned to Oilgear "Any-Speed" Fluid Power Drives, to solve what is really a complex problem ordinarily. Oilgear units provided an easy and economical means of synchronizing many machine components.

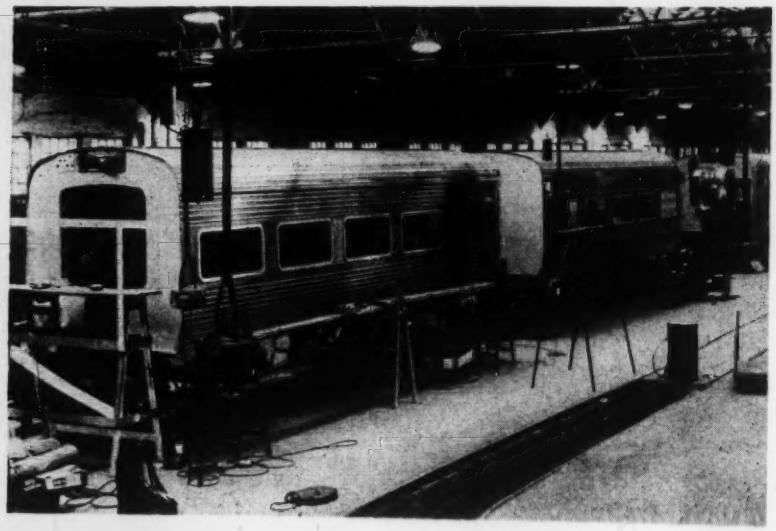
Oilgear *Any-Speed* Fluid Power Drives and transmissions *do* offer many machine design advantages including ease of control and synchronization of driven members, steplessly variable speed, fundamentally simple circuits, and long, trouble-free life. Write for Oilgear drive bulletins. THE OILGEAR COMPANY, 1568 W. Pierce St., Milwaukee 4, Wisconsin.

OILGEAR
Fluid Power

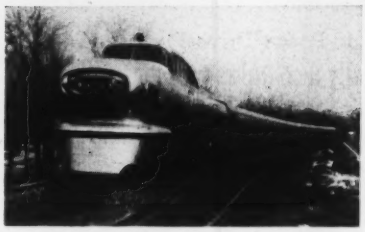
PIONEERS... NOW THREE PLANTS
FOR FLUID POWER
PUMPS, MOTORS, TRANSMISSIONS, CYLINDERS AND VALVES

its west coast operations. The program includes a new data processing center of advanced design in Los Angeles; new manufacturing, engineering, and education facilities at San Jose; and data centers in Portland and Seattle.

CHICAGO — A $5 million building program has been announced which will give Armour Research Foundation of Illinois Institute of Technology "one of the most complete industrial research centers in the world." The expansion program calls for the construction of three buildings and substantial additions to two others.



JET ROCKET has been put in service between Chicago and Peoria, Ill. by the Rock Island Railroad. Coaches are constructed mainly of stainless steel in a monocoque design. Although capable of 105 mph, the train will carry 308 passengers at a lower average speed



Helicopter Gas Turbine Nears Flight Test Stage

Development Nears End On Versatile Power Unit

SCHENECTADY, N. Y.—A small gas turbine engine, designated T58, is in advanced stages of development for the Navy Bureau of Aeronautics. General Electric revealed that the engine is in the "1000 horsepower class" and will undergo extensive helicopter rotor tests at the company's Flight Test Center in the near future.

Benefits G-E claims for the new engine are heavier payloads, higher flight speeds, and better fuel economy. Other advantages include installation flexibility and ease of maintenance. It is also said T58 can use several fuels.

Coal Bin's Black Cat To Be Intensified

Super Light Amplifier Brightens Black Scenes

NEW YORK—A new device that amplifies light electronically thousands of times will be produced commercially by Bendix Aviation.

Called the Lumicon, the new device amplifies light 40,000 to 50,000 times and reveals a blacked-out scene as a bright television picture. Linked with X-ray, it projects a bright image on a television screen but works with only low-level X-

Topics

Polite horns are promised by Studebaker-Packard. A special engineering group has been formed to devise a horn that makes a polite request instead of an insulting demand.

• • •

Number of tubes in color television receivers has been cut almost in half in the past two years. Now they average about 26 tubes compared to an original complement of 44 tubes. Another money saver is the increased use of printed circuits. RCA plans to introduce an "inexpensive" color set (about $500) in the early summer using six printed circuit boards.

• • •

Japanese family car is being produced by the Toyota Motor Co., Tokyo. Cost is about $1250. A 20-hp engine powers the 1320-lb car. Top speed is said to be about 62 mph.

• • •

Another Mercury model is being planned by Ford. This in addition to Ford's Project E being readied for possible introduction in 1957.

• • •

A 130-passenger turbo-prop airliner will be designed and developed by Bristol Aeroplane Co. Ltd. in conjunction with General Dynamics. Speed is expected to be over 500 mph.

• • •

A recently granted patent describes a device supposed to help you park your auto. Light from a lamp on the rear of your car is reflected from the other car and picked up by a photocell. Intensity of the reflected light is converted to distance on a meter on your dash. What about compensating for different reflectance values of dirty cars?

• • •

TWA has joined the airlines' move to jet transports by ordering Boeing 707's. A total of 30 of these transports will eventually be bought in the current program.

• • •

Ford reports Continental production will be stepped up 25 per cent in 1956 to meet the demand.

Facing Page—ITEM 158→

SIDELINES

are essential to

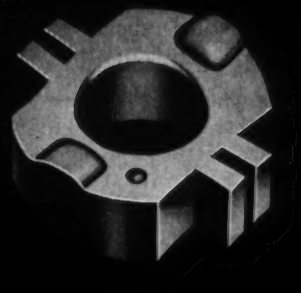
Football

Baseball

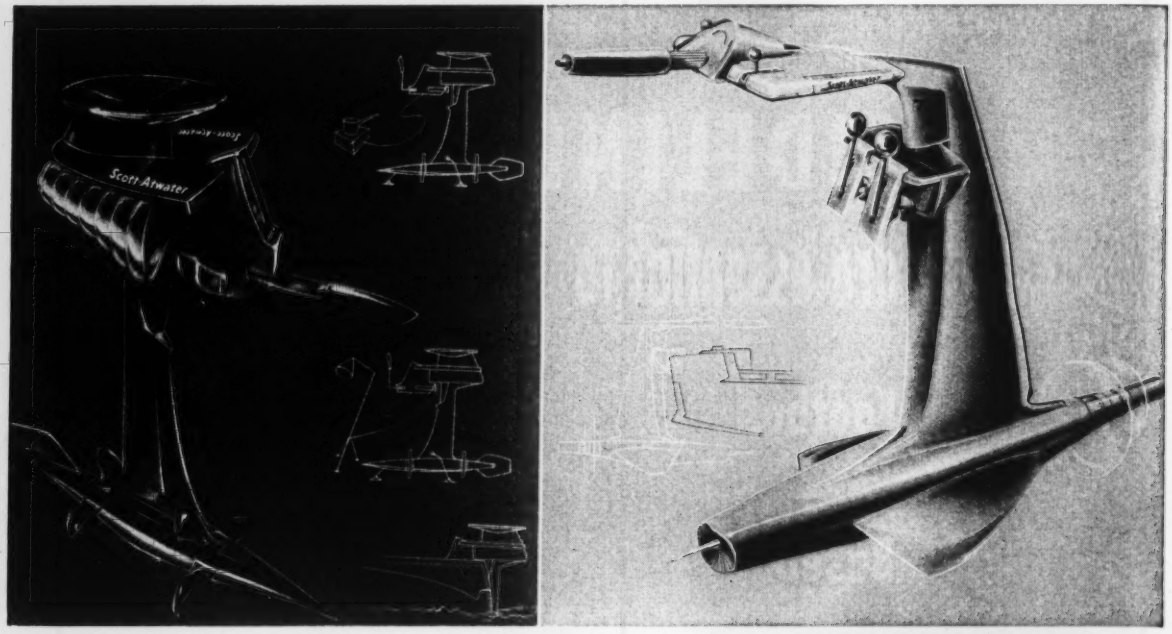
Tennis

but not to manufacturing.

Bound Brook produces no "sideline" products-only the world's finest Powder Metallurgy Bearings and Parts.....



BOUND BROOK OIL-LESS BEARING CO., BOUND BROOK, N. J. EST. 1883



GONE ALL OUT FOR OUTBOARDS is the Scott-Atwater Mfg. Co., Minneapolis, major producers of the conventional small-boat power plant. The company staff took a long look into its product's future and saw these "dream" possibilities. Above left, a sun-powered motor with power steering could be converted to operate electric camping equipment. Above right, counter-rotating propellers give vibrationless performance. Right, rotating disks under water propel a boat forward and change speed to steer it

ray energy.

Basically, the light amplifying system combines new electronic concepts and closed circuit television. It consists of a detector unit, or image orthicon tube, connected through amplifiers and cables to a monitor unit similar to a standard television picture tube. A "light tunnel" containing a fluoroscopic screen is added to the detector for X-ray purposes.

It is claimed the Lumicon will make possible immediate X-ray inspection of forgings, castings, engines in operation and similar large objects. It is also expected to make possible photographs of details on the planets, such as the canals of Mars.

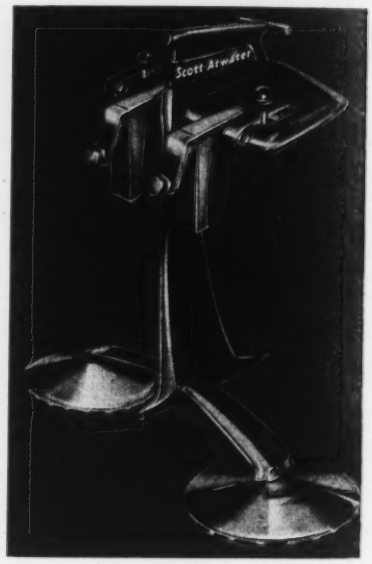
First Atom-Powered Civil Electric Station

CANOGA PARK, CALIF.—First nonmilitary atomic reactor for the generation of electricity by a public utility is now building.

Negotiations are underway between Atomics International and the Southern California Edison Co. for the sale of surplus heat from the reactor located 30 miles from Los Angeles. The agreement will permit Edison to build and operate a heat exchanger and turbogenerator with an electrical capacity of about 7500 kw.

Boon To Izaac Waltons Is Sonar Fish-Finder

COLLEGE POINT, N. Y.—An electronic "fish-finder" has been announced by Edo Corp. Called the



Fishscope, the device employs electronics and sonar to produce an image of fish below a boat from 0 to 250 fathoms (1 fathom = 6 ft). Having spotted a school, operators of the Fishscope can magnify the picture to tell the depth of the quarry and in some cases even identify individual fish.

Magnetic amplifiers is the general subject of a special technical conference to be held in the Hotel Syracuse, Syracuse, N. Y., on April 5 and 6, 1956. The conference will be cosponsored by the AIEE Committee on Magnetic

How to detect and measure flange bending in gasketed joints

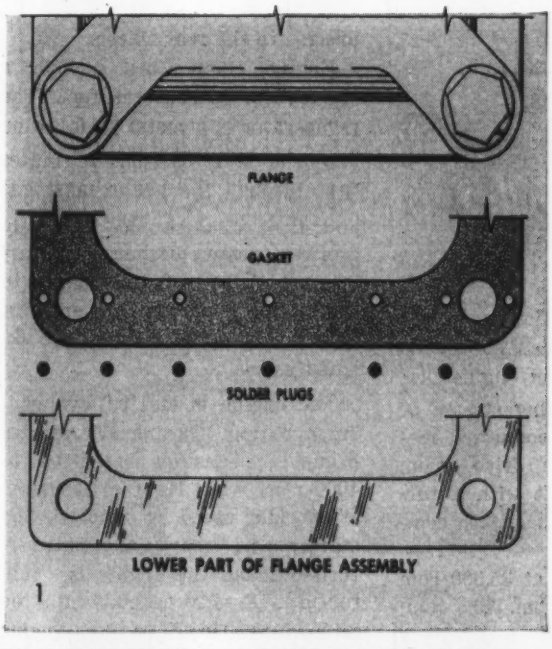
A surprisingly large percentage of gasket leaks is caused by almost undetectable bending or bowing that occurs between flange bolts, according to tests conducted at the Armstrong Research and Development Center.

Obviously, bending is most likely to be found where flanges are light, where bolts are widely spaced, or where bolting pressure is high. But it can also occur in heavy flanges, where bolts are not properly spaced.

Flange bending can cause leaks because it reduces the flange pressure on a gasket in the area midway between bolt holes and thus reduces gasket compression. Also, it may cause extrusion of the gasket near the bolts because of the concentrated pressure in these areas.

There are three qualitative ways and one quantitative way that an engineer can determine if flange bending is taking place.

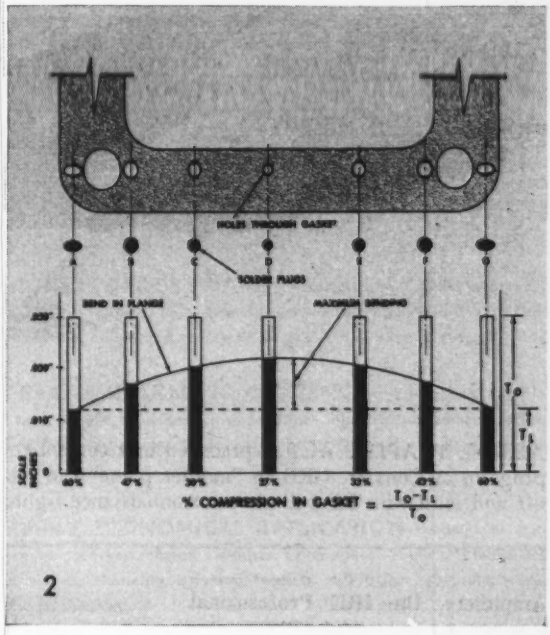
1) *Pinpoint the leakage.* If leaks originate at center points between bolts, there's good reason to believe that flange bending is the source of trouble.
2) *Look for localized extrusion.* Extrusion near bolts—and not at midway points—indicates that flange bending is present.
3) *Check for varying gasket adhesion.* Flange pressure is one of the factors causing gasket adhesion. Consequently, where pressure is greatest, greatest adhesion should occur. If upon opening a leaky joint the gasket is found to be sticking more around bolts than at center, flange bending probably is occurring.



1

TO QUANTITATIVELY MEASURE FLANGE PRESSURE or gasket compression at any particular point, a simple yet accurate "solder plug" test devised by Armstrong research engineers can be used.

Drill several holes about 1/32 inch in diameter through thickness of gasket to be tested. Insert in these holes cylinders or plugs of soft solder. (Fig. 1) The plugs should be thick enough so that when the flanges compress the gasket, the plugs will also be compressed. Put gasket with solder plugs into flange and tighten bolts to desired torque.



2

Open the flange and measure thickness of solder plugs. Each plug obviously will measure exactly the same as the compressed thickness of the gasket at the point where it was located.

The extent of flange bending can be shown graphically by charting the solder plug thicknesses. (Fig. 2) If too much bending occurs, gasket will be overcompressed around bolts and undercompressed between bolts.

The percentage of compression can be easily calculated by using the formula in Figure 2. With this information, it is possible to determine whether the gasket material is within its recommended range at specific locations on the flange. The load-compression curves for the gasket material in question may be used to estimate unit loads. But these are relative unit loads and not absolute values. In addition, picking unit loads from load compression curves is applicable only to the compressible gasket materials such as cork composition.

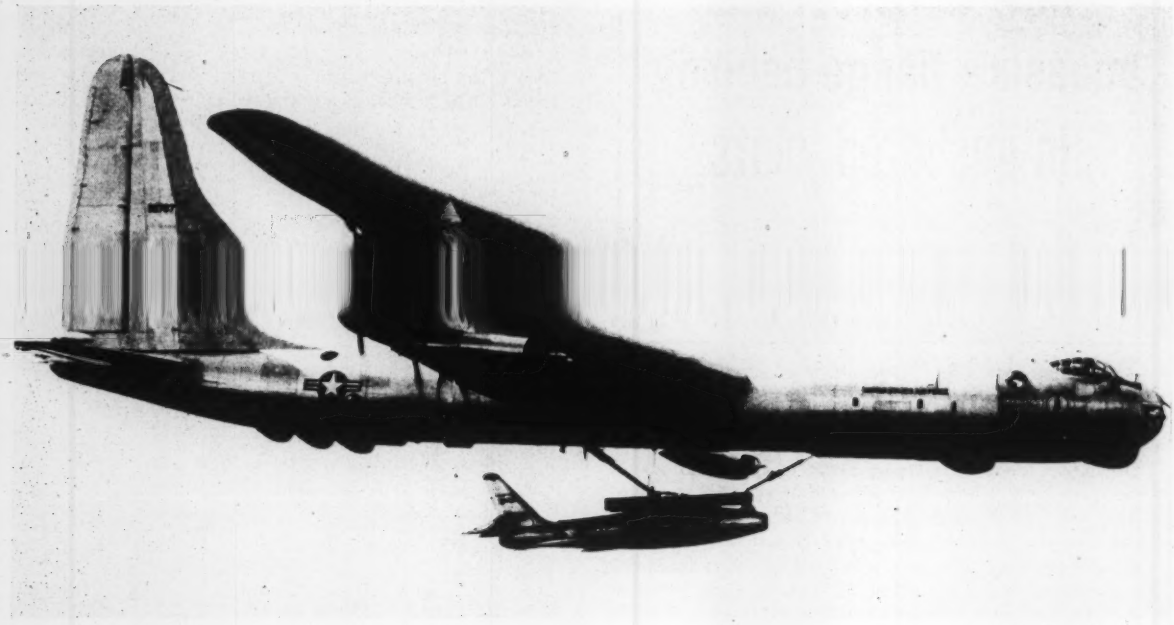
SEND FOR 24-PAGE GASKET DESIGN MANUAL

You'll find other useful information on the design and use of gaskets in the new Armstrong Gasket Design Manual. Write for your copy of this manual to Armstrong Cork Company, Industrial Division, 7103 Dean Street, Lancaster, Penna. For information on all Armstrong Gasket Materials, see Sweet's product design file.

Armstrong

GASKET MATERIALS

. . . used wherever performance counts

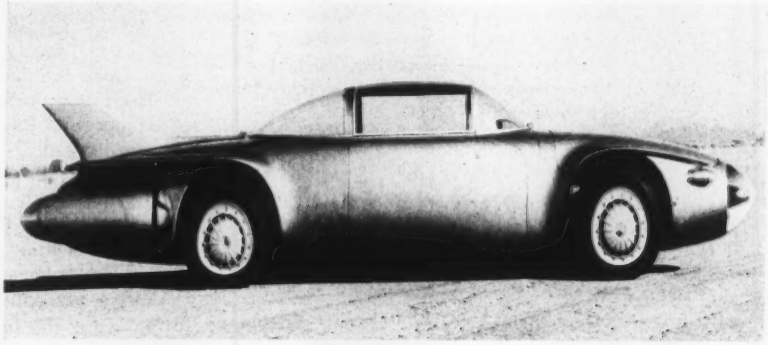


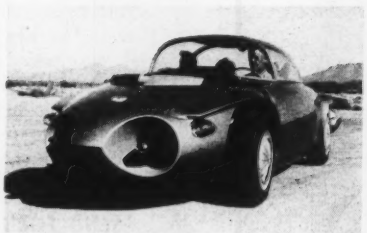
AERIAL TRAPEZE ACT is practiced in a current test program at Convair. GRB-36 "mother plane" can take off and land with RF-84F photo-reconnaissance fighter nestled in bomb bay. The fighter, equipped with "sky-hook", is launched and retreived by the GRB-36 while both planes are in flight

Amplifiers, the IRE Professional Group on Industrial Electronics and the ISA Central New York Section. More information is available from C. F. Spitzer, Bldg. 3, General Electric Co., Electronics Park, Syracuse, N. Y.

Gas-Turbine Family Car Tested

Third Experimental Car G-M Developed





DETROIT—Following two previous experimental vehicles powered by gas turbines, the Firebird II has been developed by the General Motors Research Staff.

Firebird II is the third stage in a program begun in 1949. First phase product was XP-21 Firebird, first gas turbine automobile developed in the U. S. Next was the GM Turbocruiser, world's first gas turbine bus.

The power plant of Firebird II is a new Whirlfire engine weighing about 850 lb including acessories. It generates more than 200 hp at 35,000 rpm gasifier speed. The power turbine speed is 28,000 rpm. Maximum gas temperature is 1650 F.

Designated GT-304, the engine has independent gasifier and power sections. The gasifier section is essentially a small jet engine that produces a fast-moving stream of hot gas. It is not connected mechanically with the drive train, being simply a shaft with a turbine at one end and an air compressor at the other.

The gasifier spins at 35,000 rpm and idles at 15,000 rpm. The compressor operates at a pressure ratio of 3.5 to 1. The power turbine is geared through a transmission to the rear wheels.

Engine components include a regenerator to conserve fuel. The regenerator is a metal mesh drum, driven at 20 to 30 rpm. It rotates first through the hot exhaust gas and then through the relatively cool compressor discharge air, carrying the heat from the exhaust to the incoming air. It recovers over 80 per cent of the heat in the exhaust gas.

The engine is started by pushing a button. The electric starter brings the gasifier speed up to 4000 rpm, when the fuel turns on. When idle speed is reached, the starter and spark automatically turn off, and the engine is ready for use. A silencer built into the nose of Firebird II muffles engine noise.

An alternating current genera-

New ROTO-MATION TORQUE MOTOR

For Oil or other Pressure Mediums.
Pressure Against Vane Reciprocates Shaft.

TYPICAL TORQUE RATINGS (IN.–LBS.)
Single Vane Units—280° Arc both directions

BORE SIZE	Vane Length	100 PSI	500 PSI	1000 PSI	WT. LBS.
3"	2"	150	750	1500	15
	4"	300	1500	3000	21.5
	6"	450	2250	4500	28
6"	3"	1000	5000	10,000	92
	6"	2000	10,000	20,000	104
10"	5"	5000	25,000	50,000	286
	8"	8000	40,000	80,000	312
	12"	12,000	60,000	120,000	387
20"	6"	30,000	150,000	300,000	1620
	12"	60,000	300,000	600,000	2100

NOTE: Double Vane Units double torque with same pressures, but rotation is limited to 100° in both directions.

✓ **HIGHER TORQUE OUTPUT**—special neoprene and teflon vane seals minimize leakage . . . insure greater power. Speeds limited only by fluid pressure volume. Full torque power obtainable in fraction of a second.

✓ **GREATER OPERATING EFFICIENCY**—through superior design of special vane seals and close tolerance fitting of all parts. Operates at 95 to 98% efficiency, withstands heat up to 200°F. Special models and seals for higher temperatures.

✓ **SIMPLE, ECONOMICAL APPLICATION**—eliminates complex linkages, sprockets, chains, cylinders. Saves space. Applicable to turning, opening, closing, clamping, indexing, feeding, pushing, or moving any type of load or mechanism.

✓ **LONGER SERVICE LIFE**—fewer moving parts, precision machined components, bronze nut and thrust bearings, chrome vanadium and chrome-moly steel shafts. No external leakage.

COMPACT, RUGGED, ADAPTABLE TO A WIDER RANGE OF APPLICATIONS

The new ROTO-MATION Oscillating Torque Motor is a simple, more versatile hydraulic-pneumatic device especially designed to produce more torque power (1,800,000 in.-lbs. from 20" bore) to serve a wider variety of automation applications. Compact and rugged, the new motor is easily adaptable to original equipment or as a replacement unit. Wide ports and flange-type connections meet J.I.C. standards. Extensive tests prove that performance life is many times greater than any device previously manufactured. The square shape facilitates easy mounting on any of six faces. There are 14 mounting models available and four shaft styles. Units are complete with standardized controls, fittings, and auxiliary devices. Sizes are available for moving loads ranging from a few ounces to many tons.

Write **FOR COMPLETE SPECIFICATIONS**—New catalog provides complete specifications, illustrates and describes wide variety of applications, and contains complete torque load graphs.

ROTO-MATION INC.

NOW A SUBSIDIARY OF PINES ENGINEERING CO., INC.

947 E. SATER STREET • GREENVILLE, OHIO

ATION MOTORS, CONTROLS, AND AUXILIARY TRANSMISSION EQUIPMENT

—ITEM 160—

tor for the charging system delivers 100 amps at idle speed. The charging system uses a rectifier to produce direct current for the car's 12-volt battery. Generator output is controlled by a new transistor voltage regulator.

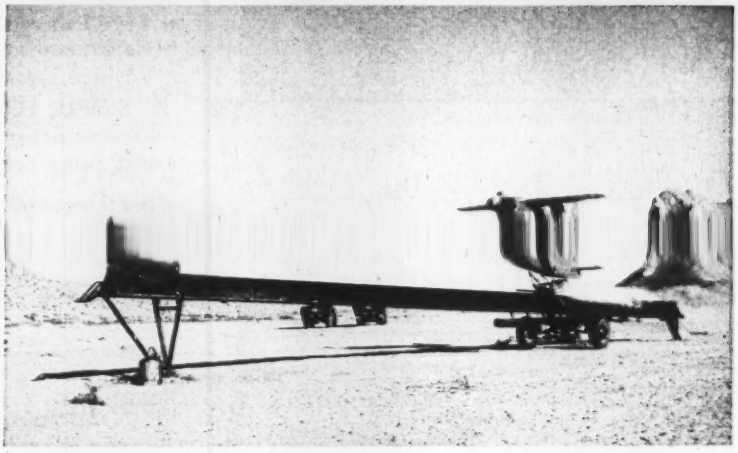
An electrical gearshift employs a two-step solenoid. When the driver sets the shift selector in "drive" position, one part of the coil is energized and the plunger moves in part way. When the "reverse" position is selected, the plunger moves in the rest of the way. A mechanical linkage between the plunger and the transmission performs the desired shifts.

Firebird II has a 120-in. wheelbase, overall length is 235 in. and height is 52 in. at the tail fin.

Biggest Hammer To Pound Piles in Ocean Floor

DOVER, N. J.—The world's most powerful pile driver has been completed recently by the McKiernan-Terry Corp. It will be used in the construction of new oil drilling platforms in the Gulf Tidelands. As exploration for oil moves farther from shore, the piles securing the towers must be driven through deeper water into the ocean floor.

The new hammer is 3 ft square, 15 ft high, weighs 20 tons and has a 10-ton ram. It delivers 60 blows per minute at 60,000 ft-lb. It is driven by steam fed through 3-in. hose from 150 hp boiler.



TAKING PICTURES WITHOUT TAKING RISKS is the military employment of this pilotless aircraft developed by Radioplane Co. Designated RP-71, this is an adaptation of a standard target drone. Under radio control, the photo-reconnaissance version is launched with jet assist, climbs at 2300 fpm, flies at 227 mph and takes still or motion pictures at altitudes up to four miles. Newer drones to do the same job have jet engines. glass fiber construction and fly at 350-400 mph

Electric Sniffer Smells Smog

LAFAYETTE, IND.—Something new on the electronic countenance is an "electric nose" for measuring air pollution. Under development at Purdue University, the instrument cannot differentiate between odors, but it can measure atmospheric contamination present in minute quantities.

Development of the instrument evolved from experiments which showed that the sensitivity of contact potential difference measurements to surface impurities can be used to provide a measure of the amount of odorous contamination in the atmosphere. A number of odorous materials, when present in concentrations of only a few parts per million, are absorbed on test surfaces in amounts sufficient to change the contact potential difference measurements by several millivolts.

Although the technique is still in the laboratory stage, members of the Purdue University staff say that ultimately it may be possible to expose a variety of sur-

faces to the atmosphere simultaneously, direct the responses into a computer and thereby obtain a good deal of information about the kinds and amounts of contamination in the atmosphere.

Test Chamber Makes Strains in 3-D

ITHACA, N. Y. — A hangar-sized test chamber on the Cornell campus is giving university engineers a better tool for finding out how structures and materials react to the stresses and strains of actual use.

The Cornell facility acts as a huge testing machine, capable of pulling, squeezing, bending and twisting structures as big as a medium-sized house. Its ability to put a structure to three-dimensional tests is said to give it an advantage over conventional testing devices in the same range. The chamber can handle full-scale bridge and airplane components and other units of similar size. Forces and loads can be applied from ceiling, floor and side walls in various combinations.

Full-size light-gage steel floor-decks up to 12 by 30 ft in area have been tested with and without concrete fill, and with various types of welding. "Loading cells" mounted on the walls and columns simulate the horizontal forces caused by earthquakes.

Details of a treatment which produces **cementable surfaces on Teflon plastic parts** will be made available by Du Pont. Teflon is normally very slick and notable for its refusal to stick to anything.

After the Du Pont treatment, Teflon can be bonded satisfactorily with conventional adhesives to various materials including itself. The treatment has been found not to affect the other properties of the plastic.

Anticipated uses for the treated material are in the installation of liners and covers for pipe or ducts and the attachment of facings onto valve and machine parts. The

(*Continued on Page 22*)

(Advertisement)

DRAFTING TRENDS

At Universal Oil Products Company, Chief Draftsman M. F. Perkins checks the working qualities of Post pencil cloth with Joe Mania of the Drafting Division.

More drafting rooms use pencil cloth for ink-like lines at pencil speed

We've noticed that more and more drafting rooms are using pencil cloth for important originals. (We're particularly interested because Post was the first U. S. manufacturer of pencil cloth.)

While cloth is naturally more expensive, many draftsmen feel that the cost is nominal compared with the expensive time and effort that goes into an original drawing. They feel that paying a little more for the *durability* of cloth is a common-sense investment.

For speed and ease of working, pencil cloth is probably the best medium of all. Many draftsmen use it for drawing, primarily because of its easy working matte surface and good erasability. At pencil speed, it gives a jet black line with density approaching ink. Reproduction from pencil cloth is consequently very good—sharp and precise with excellent contrast.

Two good examples of recent improvements in pencil cloth are Post's *Whitex* and *Penciltex* (blue tint). Both are available in either regular or smooth surfaces for different degrees of pencil hardness. The texture is precisely formulated for dense, opaque lines at high drawing speeds. All are moisture-resistant and highly transparent.

The most popular feature of *Whitex* and *Penciltex* is the unusual erasability. Even 6H pencil lines erase without "ghosting". Just as important, they hold up well after working and reworking in one place. Our researchers are constantly testing different tracing cloths and they tell us that *Whitex* and *Penciltex* have the finest erasing qualities of all leading cloths ■

New mathematical chart

A new chart called "Calculine" performs multiplication, division and logarithmic problems quickly and accurately. The chart is furnished on 8½ x 11" heavy card stock with grid lines and diagonals printed in green. Engineers can use it in the office or in the field, computing with one hand while the other is free. There are no delays involved making time-consuming settings. After numerous experimental designs, "Calculine" was devised by E. J. George, an engineer at Sun Oil Company, for students in his courses at Drexel Institute. The charts are distributed exclusively by Post.

Further information on these items is available from the Reader Service Division of the Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18.

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SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

—ITEM 161—

For More Information Circle Item Number on Yellow Card—page 19

We welcome inquiries

We are specialists in the custom-building of the types of gears shown here. We make them in quantity to your specifications.

Manufacturers who want that kind of wide specialization—and who are looking for a company that can serve as a "gear department" are indeed invited to write or phone. The answer will be prompt.

*REG. U. S. PAT. OFF.

DOUBLE DIAMOND GEARS
TRADE MARK

FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

Automotive Gear Works, inc.

ESTABLISHED IN 1914

RICHMOND, INDIANA

Reader Information Service

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for More Information . . .

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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Page No. Title of Article

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MACHINE DESIGN
MAR. 8, 1956

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1	31	61	91	121	151	181	211	241	271	301	331	361	391	421	451	481
2	32	62	92	122	152	182	212	242	272	302	332	362	392	422	452	482
3	33	63	93	123	153	183	213	243	273	303	333	363	393	423	453	483
4	34	64	94	124	154	184	214	244	274	304	334	364	394	424	454	484
5	35	65	95	125	155	185	215	245	275	305	335	365	395	425	455	485
6	36	66	96	126	156	186	216	246	276	306	336	366	396	426	456	486
7	37	67	97	127	157	187	217	247	277	307	337	367	397	427	457	487
8	38	68	98	128	158	188	218	248	278	308	338	368	398	428	458	488
9	39	69	99	129	159	189	219	249	279	309	339	369	399	429	459	489
10	40	70	100	130	160	190	220	250	280	310	340	370	400	430	460	490
11	41	71	101	131	161	191	221	251	281	311	341	371	401	431	461	491
12	42	72	102	132	162	192	222	252	282	312	342	372	402	432	462	492
13	43	73	103	133	163	193	223	253	283	313	343	373	403	433	463	493
14	44	74	104	134	164	194	224	254	284	314	344	374	404	434	464	494
15	45	75	105	135	165	195	225	255	285	315	345	375	405	435	465	495
16	46	76	106	136	166	196	226	256	286	316	346	376	406	436	466	496
17	47	77	107	137	167	197	227	257	287	317	347	377	407	437	467	497
18	48	78	108	138	168	198	228	258	288	318	348	378	408	438	468	498
19	49	79	109	139	169	199	229	259	289	319	349	379	409	439	469	499
20	50	80	110	140	170	200	230	260	290	320	350	380	410	440	470	500
21	51	81	111	141	171	201	231	261	291	321	351	381	411	441	471	501
22	52	82	112	142	172	202	232	262	292	322	352	382	412	442	472	502
23	53	83	113	143	173	203	233	263	293	323	353	383	413	443	473	503
24	54	84	114	144	174	204	234	264	294	324	354	384	414	444	474	504
25	55	85	115	145	175	205	235	265	295	325	355	385	415	445	475	505
26	56	86	116	146	176	206	236	266	296	326	356	386	416	446	476	506
27	57	87	117	147	177	207	237	267	297	327	357	387	417	447	477	507
28	58	88	118	148	178	208	238	268	298	328	358	388	418	448	478	508
29	59	89	119	149	179	209	239	269	299	329	359	389	419	449	479	509
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FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

—4c POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

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Penton Building
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Reader's Service Dept.

"STOCK ANSWER"
to many a design problem

ALLEN DOWEL PINS

ALLEN DOWEL PINS are being profitably employed in a thousand and one ingenious ways beyond their conventional applications in tool and die work — as economical roller bearings, as axles, precision plugs, hinges and wrist pins to name a few.

If you have an application that will utilize the great strength, accuracy and fine finish of Allen Dowel Pins, you can save substantially on the cost of your product — because you can secure them at favorable prices right from your Allen Distributor's stock.

Check the quick facts at the right and write directly to Allen's Engineering Department for further technical information.

SPECIFICATIONS

- Made from Allenoy heat treated steel. Surface hardness 62-64, Rockwell C scale; core hardness 52-54. Case depth .010″ to .020″ depending on size.
- Single shear strength 160,000 to 180,000 p.s.i.
- Surfaces precision ground to ± .0001″ with micro-inch finish of 6 RMS max.
- Sizes: Diameters, ⅛″ to 1″. Lengths, ⅜″ to 6″.
- Two standard oversizes — .0002 for press fits between mating parts, or .001 for repair work, or holes machined oversize.

ALLEN HEAD
ALLEN

—ITEM 163—

For More Information Circle Item Number on Yellow Card—page 19

Profitable Facts

straight from the horse's mouth

Carbon, one of the world's most versatile elements, is constantly finding new and diversified applications throughout industry. Here are some profitable facts that prove the versatility of carbon:

Good Electrical Conductivity – Carbon brushes and contacts, vacuum tube anodes, grid rectifier anodes, and welding products.

Resistant to Corrosion—Bearings for use in acids, plating electrodes, pipe for handling chemicals, linings for acid tanks.

Self-Lubricating – Carbon piston rings, dash pot plungers, nozzles, seals, orifices and inserts in metal bearing surfaces and brake shoes.

No Deformation at High Temperatures —Sintering boats, brazing boats and fixtures, molds for powder metallurgy, dies for continuous casting, forms for metal to glass sealing.

Resistance to Severe Thermal Shock – Liners for rocket nozzles, electric furnaces, hearth and wall sections of blast furnaces.

Easily Machined and Fabricated—Carbon structural shapes—beams, blocks, plates and rods.

Speer Carbon Company can provide practically any product for your need, made to exacting specifications for shape, size, and composition. The services of Speer's competent technical service staff are available to assist you in the proper selection of carbon products and in their application to all types of industrial equipment. Return coupon for details.

SPEER Carbon Co.

St. Marys, Pa.

Please send information on carbon for use in_____

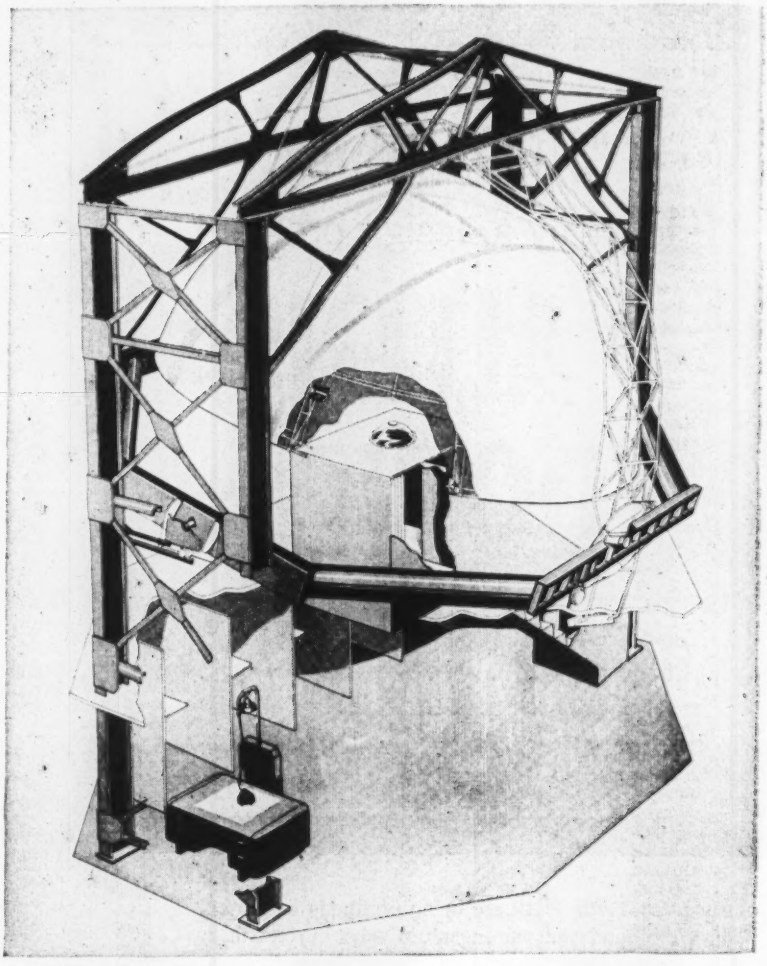
Name_____

Title_____

Address_____

City_____ State_____

—ITEM 164—



SPACE-TRAVEL FLIGHT-SIMULATOR conceived by the Navy, is expected to look like this. It must be built before crew-carrying rockets can be released. Similar in part to present aircraft trainers, the space-trainer must simulate exceedingly fast ascent, change of mass and path of craft. A celestial navigation system will use spherical space coordinates

(*Continued from Page* 15)

treatment is expected to be valuable also in applications where anti-stick properties are of prime importance.

Less noise from jet aircraft engines is the goal of research and testing in progress at Boeing Airplane Co., Seattle. A Boeing engineer has said that work to date has reduced the noise "by amounts which could result in jet aircraft considerably quieter than present day operating transport aircraft." Tests have been performed on the Boeing 707, first American jet transport, now in production. It was pointed out that engine and plane performance must be sacrificed to reduce noise. An optimum state between the two desirable conditions has not yet been determined.

New Experimental Controllers Test Transistors

PITTSBURGH, PA.—Two recent experimental designs of control devices by Westinghouse engineers give indications of the possibilities for future industrial applications for transistors.

A new hot-metal detector utilizes a phototransistor as an infra-red sensing device, and also uses transistors in the amplifying circuit. It can be used in any application where a metal object at 700 F or more must be detected and a

NEW V-LOCK TEENUTS.

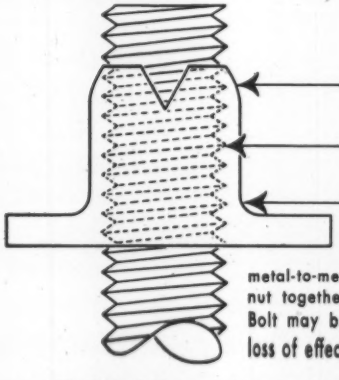
PATENT APPLIED FOR

- **self-locking**
- **vibration-proof**
- **one-piece construction**
- **proven effectiveness**
- **highly adaptable**
- **re-usable**

The upper portion of this precision-made Teenut incorporates a V-type notch with the circumference of the barrel compressed inwardly toward the axis to form a permanent set. This makes it a re-usable, prevailing-torque-type, self-locking nut.

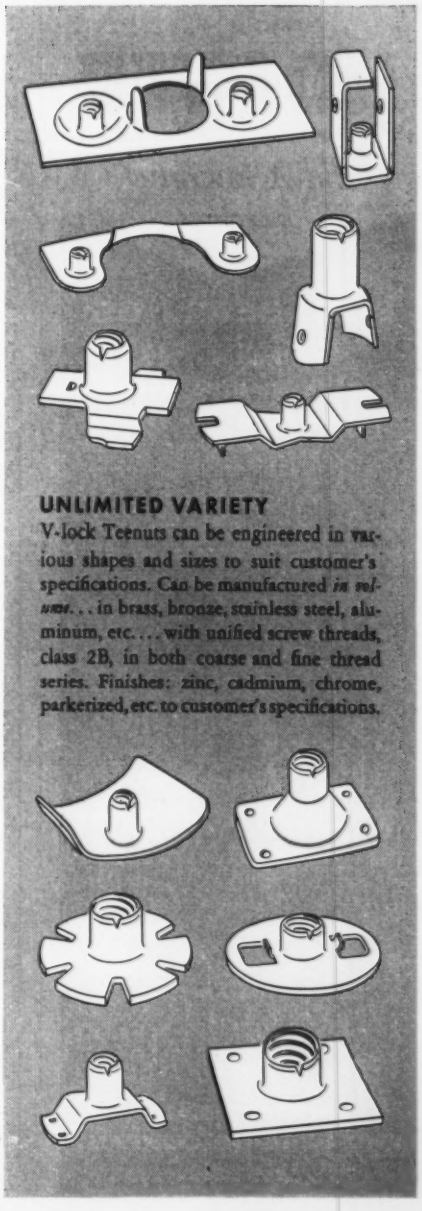
It is a one-piece, self-contained unit in which the self-locking device is an integral part of the design. No non-metallic materials or stamped parts are used so that the V-lock Teenut is not affected by heat or oils and has high tensile strength.

As the V-lock Teenut does not rely on base load to obtain its friction grip, it may also be used as a stop nut. (Indentations in base flange are welding bosses).



Bolt spins freely into nut until it reaches gripping area. Then, spring action creates strong, metal-to-metal wedging force, locking threads of bolt and nut together to make assembly virtually vibration-proof. Bolt may be removed and replaced many times without loss of effectiveness in nut.

The V-lock Teenut is but one of thousands of special purpose fasteners designed and manufactured by United-Carr to help speed assembly, cut costs and improve product performance. For further information on the V-lock Teenut or for help with any other fastening problem, consult your nearest United-Carr field representative or write us for his name and address.



UNLIMITED VARIETY

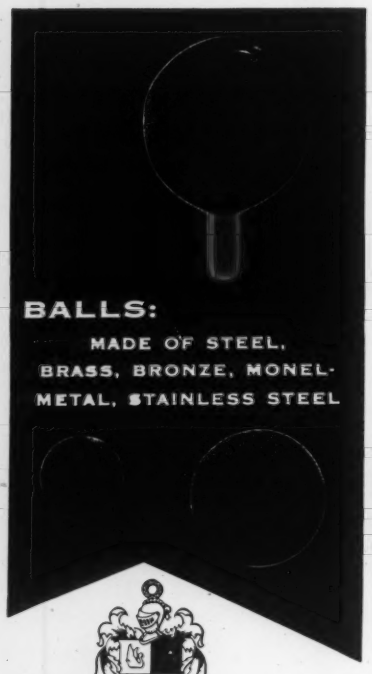
V-lock Teenuts can be engineered in various shapes and sizes to suit customer's specifications. Can be manufactured *in volume*... in brass, bronze, stainless steel, aluminum, etc.... with unified screw threads, class 2B, in both coarse and fine thread series. Finishes: zinc, cadmium, chrome, parkerized, etc. to customer's specifications.

UNITED-CARR FASTENER CORPORATION

31 Ames Street Cambridge 42, Mass.

MAKERS OF DOT FASTENERS

—ITEM 165—



HOOVER

The Aristocrat of Bearings

BALL BEARINGS:
AMERICA'S ONLY
BALL BEARING WITH
HONED RACEWAYS

HOOVER BALL
AND BEARING COMPANY
ANN ARBOR, MICHIGAN

—ITEM 166—

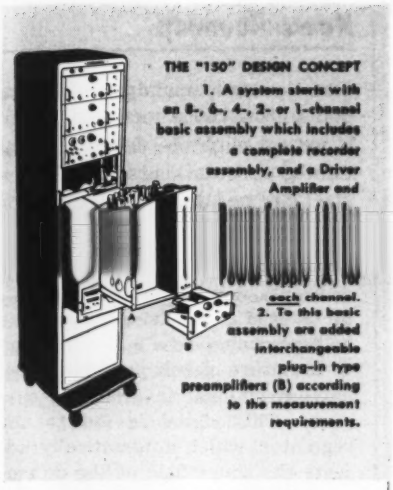
FULL-BLOWN AIRPLANE has been developed by Goodyear Aircraft Co., Akron, O. This inflatable craft can be deflated and packed in a trunk. It was built to test the possibilities of new rubberized fabric as structural material for aircraft. The light-weight plane is made rigid by air pressure

signal transmitted.

One example is in the rolling of steel tubing. With a specified volume of metal to start with, and a constant outside diameter, thickness of the tube wall can be determined by tube length. If the pipe is rolled with too thin a wall, the pipe will be longer than average. If the wall is too thick, the tube will be shorter. Wall thickness can thus be determined from tube length. By placing several hot-metal detectors at specified distances apart, the length of the pipe can be measured and thus the wall thickness is determined.

The second experimental device is a constant-current motor control which uses static semiconduc-

LARGEST VACUUM MELTING FURNACE is now in operation at Vacuum Metals Corp., Syracuse, N. Y. The melting unit is enclosed by a liquid-cooled chamber of ¾-in. stainless steel. Access is through air lock. From one console, operator controls charging, mold transfer and pouring operations



THE "150" DESIGN CONCEPT

1. A system starts with an 8-, 6-, 4-, 2- or 1-channel basic assembly which includes a complete recorder assembly, and a Driver Amplifier and Power Supply (A) for each channel.
2. To this basic assembly are added interchangeable plug-in type preamplifiers (B) according to the measurement requirements.

HERE'S REAL oscillographic RECORDING VERSATILITY

DEMONSTRATED AT BOOTHS 455 AND 457 ELECTRONICS AVENUE I.R.E. SHOW

A Sanborn "150 Series" System can be set up to record any of these inputs in any of the channels

AC or DC Signals,

AC-DC Preamp

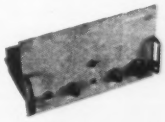
balanced or single-ended, with sensitivity of 1 mv to 2 v/cm (AC), 1 mv to 2 v/mm (DC).

Logarithmic Level Signals

LOG-AUDIO Preamp

Audio signals (20 cycles to 20 KC) or DC voltages recorded in logarithmic fashion on 50 decibel chart.

Higher Level Signals,



INPUT COUPLING NETWORK

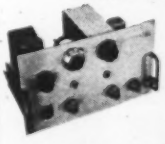
where maximum sensitivity of 1 v/cm, and input impedance of about 200,000 ohms are adequate.

Magnitude and Direction of Physical Variables,

CARRIER Preamp

with variable resistance, differential transformer or variable reluctance transducers.

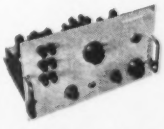
Extremely Low Voltages and Currents,



LOW LEVEL Preamp

at sensitivities of 100 μv and 1 μa per cm. (with external shunt of 100 cycles), by means of DC chopper circuit.

RMS Values of AC Voltages, Currents,



VOLT/AMMETER Preamp

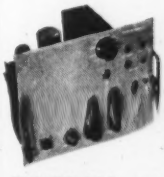
from 25-250 volts, 50 ma — 1 amp.

AC Voltage Components

SERVO MONITOR Preamp

in phase or 180° out of phase with a reference voltage (e.g., servo error signal).

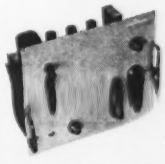
Low Level Signals,



STABILIZED DC Preamp

with extreme stability, high gain, and greater bandwidth than with 150-1500 Low Level Preamplifier.

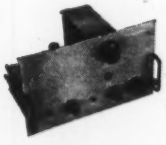
Symmetric or Asymmetric Wave Form Inputs,



FREQUENCY DEVIATION Preamp

in 350-450 cycles (2 cycles/mm) and 375-425 cycles (1 cycle/mm) ranges.

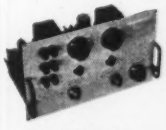
DC Signals



DC COUPLING Preamp

(push-pull, single-ended or difference between two). Basic sensitivity 50 mv/cm to 50 v/cm.

Average Value of AC Watts in a Circuit,



AC WATTMETER Preamp

in ranges from 25 volts x 40 ma to 250 volts x 2 amps. (with internal multipliers and shunts which can handle up to 4 amps).

INTRODUCED AT I.R.E. SHOW

COMPLETE, SELF-CONTAINED EIGHT-CHANNEL SYSTEM ADDED TO 150 SERIES

Model 158-5490 is intended primarily for use with analog computers but capable of other types of recording. Features include 0.1v/cm sensitivity, push-pull or single-ended input, 5 meg. input impedance each input lead to ground. Frequency response is flat to 20 cps, down 2 db at 60 cps for all amplitudes to 4 cm peak to peak.

AND, in addition to this great versatility, *equally valuable* to the user are the basic design features of Sanborn oscillographic recording systems, many of them available *only* in Sanborn equipment. They include inkless recording in true rectangular co-ordinates; improved overall linearity; numerous chart speeds; a choice of vertical mobile-cabinet or portable-case packaging; availability of 2-, 4-, 6- and 8-channel systems especially designed for recording analog computer outputs.

Sanborn engineers will be glad to help you select the equipment best suited to your needs. Contact them with confidence, and ask for a copy of the new and complete "150 Series" catalog.

SANBORN COMPANY, CAMBRIDGE 39, MASSACHUSETTS

—ITEM 167—

structures

STRESS ENGINEERS · STRUCTURES ENGINEERS · WEIGHT ENGINEERS · LOADS ENGINEERS · DYNAMICS ENGINEERS · FLUTTER ENGINEERS · COMPUTER SPECIALISTS · MECHANICAL ENGINEERS · CIVIL ENGINEERS

Expansion within Northrop Aircraft's Structures Department is creating an urgent demand for qualified personnel in all phases of guided missile, piloted aircraft, and equipment development. Included among the most critical job openings are positions for:

Stress Department—Mechanical or Civil Engineers to design missile ground handling equipment. An opportunity for men without aircraft experience to take advantage of the aircraft pay scale.

Structures Research—Creative engineers for three vital phases of Structural Research and Development: Thermo-Structural Analysis, High Speed Computing Technique Development and Structural Materials Research.

Weight Engineering—Junior Weight Engineers for diversified phases of missile and aircraft projects. Excellent opportunities for advancement in a relatively small department.

Dynamics—Experienced flutter engineers required for work on a variety of dynamics problems including flutter models, analytical work involving electronic computers, and methods development.

Loads—Exciting and diversified assignments in the fields of both piloted and pilotless aircraft are now available in Structural Loads Group for engineers of all experience levels.

Stress Department—Experienced Structural Engineers for positions on Long Range Interceptor Project and on advanced missile designs.

A wide diversification of assignments within each field of specialization awaits the men capable of filling the above assignments. Responsibilities will include work on many phases of missile and aircraft design, guidance systems and boundary layer research.

If you qualify for any of these challenging opportunities, we invite you to contact Manager of Engineering Industrial Relations, Northrop Aircraft, Inc., 1016 East Broadway Hawthorne, California, or call ORegon 8-9111, Extension 1893.

NORTHROP AIRCRAFT, INC.

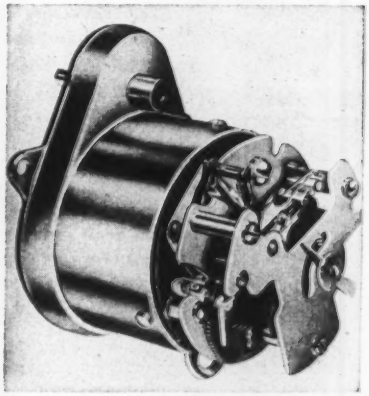
PIONEERS IN ALL WEATHER AND PILOTLESS FLIGHT

5-A-49-B

tor elements, mainly transistors and silicone-diode rectifiers. Such a control might be used for maintaining constant horsepower on a steel mill reel drive. In the experimental model a ¾-hp dc shunt motor is used as a driving motor. The voltage drop across a shunt in the dc armature circuit provides a signal proportional to armature current. This signal is fed to the regulator, which automatically adjusts the shunt field of the dc motor to maintain constant armature current and thus constant horsepower.

D-C Timing Motor Has Clock Escapement Governor

WATERBURY, CONN.—New dc timing motors developed by the A. W. Haydon Co. combine a mechanical clock escapement with an electric motor. The devices are intended



for automatic controls and various timers or computers in which the timing motor must drive a mechanism.

The beat rate of the escapement is claimed to be held constant within ±0.1 per cent for line voltage variations of ±20 per cent and load variations from zero to full load. Escapements are 300-beat or 900-beat types giving 150 or 450 complete oscillations per minute. Motors are supplied with self-contained gear reduction and output shaft. Unit weight is 7.5 oz.

A lever in the timer is operated by a cam geared to the motor. The lever extends between a pair

—ITEM 168—
For More Information Circle Item Number on Yellow Card—page 19

of leaf spring contacts. Rotation of the motor in either direction causes the lever to open the contacts. An arm of the pallet in the escapement also extends between the spring leaves. It closes the contacts at intervals fixed by the motion of the balance wheel. The unit is reliably self-starting because contacts are closed when the current is turned off.

Meetings

AND EXPOSITIONS

March 25-29—

American Society for Metals. Tenth Western Metal Congress and Exposition to be held at the Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles, Calif. W. H. Eisenman, 7301 Euclid Ave., Cleveland 3, O., is managing director.

March 26-28—

American Management Association. Manufacturing Conference to be held at the Statler Hotel, Detroit, Mich. Additional information may be obtained from society headquarters, 330 West 42nd St., New York 36, N. Y.

March 26-28—

American Society of Mechanical Engineers. Instruments and Regulators Division Conference to be held at Princeton University, Princeton, N. J. Additional information may be obtained from society headquarters, 29 West 39th St., New York, N. Y.

April 1-5—

American Society of Mechanical Engineers. Oil and Gas Power Division Conference to be held at the Jung Hotel, New Orleans, La. Additional information may be obtained from society headquarters, 29 West 39th St., New York, N. Y.

April 2-4—

American Institute of Electrical Engineers. South West District Meeting to be held at the Baker

Mor-Grip v-belts

Maurey *engineers* v-drives for every situation; the "stop and go" spurts of refrigeration drives; the pulsating, high torque loads of rock crushing; the smooth, steady-pull of textile drives... for short centers, and wide range of speed ratios. Maurey V-drive equipment has proved its value since 1917, improving the performance, and increasing the sales of thousands of products. Maurey delivers pulleys, belts and accessories *quickly* from complete stocks. Whether you are designing a new v-drive or improving an old one, contact Maurey. Call your local Maurey Distributor, or write direct.

Request these catalogs

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maurey manufacturing corp.

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—ITEM 169—

For More Information Circle Item Number on Yellow Card—page 19

MECHANICAL ENGINEERS

with experience in design of:

- Precision Mechanisms
- Radar Antenna pedestals and mounts
- Lightweight Structural members.

The recent expansion of our engineering facilities makes it possible to offer unusual opportunities to experienced creative engineers.

Beginning salary range: $6000 to $10,000.

A brief resume form and a brochure describing our new laboratory may be obtained by writing to Mr. Robert E. Doherty.

At Raytheon's new Wayland Laboratory Mechanical and Electrical engineers work together as a team to create the custom designed equipment which has enhanced Raytheon's reputation for *"Excellence in Electronics"*.

RAYTHEON MANUFACTURING COMPANY

WAYLAND LABORATORY WAYLAND, MASS.

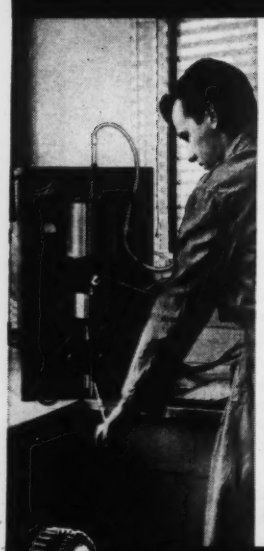
RAYTHEON

- *Full tuition paid for accepted educational programs.*
- *Location convenient for country or city living.*
- *Progressive salary review system.*
- *Liberal employee benefit program.*

—ITEM 170—

Another of the Reasons Behind Brad Foote Quality—

CARBON DETERMINATION



• In hardening gear teeth by carburizing, carbon content and depth of penetration are vitally important. BRAD FOOTE insures precise control of these factors through metallurgical tests with equipment developed specifically for this purpose.

• A test bar goes through the complete carburizing and heat-treating cycle with every batch of carburized gears. Shavings are taken from this bar at carefully measured depths. Chemical analysis of these shavings gives complete and precise data on carbon content and penetration.

• Carbon determination tests are only one of many metallurgical controls that insure the uniform quality of BRAD FOOTE Gears. Metallographic examination, hardness testing, chemical analysis—these are just a few of the quality checks provided by BRAD FOOTE's completely equipped metallurgical laboratories.

• Add these precise controls to specialized production and heat-treating equipment and a wealth of detailed experience in producing gears of all types—you begin to appreciate why BRAD FOOTE can produce better quality gears at substantial savings.

• Find out how BRAD FOOTE quality can save you money. Send us the specifications on your next job for quotation. No obligation of course. BRAD FOOTE MAKES ALL TYPES OF GEARS—IN A COMPLETE RANGE OF STYLES AND SIZES

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subsidiaries | AMERICAN GEAR & MFG. CO. Lemont, Illinois • Phone Lemont 920 | PITTSBURGH GEAR COMPANY Pittsburgh 25, Penn. • Phone SPalding 1-4600

—ITEM 171—

News Roundup

Hotel, Dallas, Texas. Additional information may be obtained from society headquarters, 33 West 39th St., New York, N. Y.

April 4-6—

American Society of Lubrication Engineers. Annual Meeting and Exhibit to be held at the William Penn Hotel, Pittsburgh, Pa. William P. Youngclaus, Jr., 84 E. Randolph St., Chicago 1, Ill., is administrative secretary.

April 4-7—

National Screw Machine Products Association. Annual Meeting to be held at the Schroeder Hotel, Milwaukee, Wis. Additional information may be obtained from society headquarters, 2860 E. 130th St., Cleveland 20, O.

April 8—

Packaging Machinery Manufacturers Institute. Spring Meeting to be held at the Dennis Hotel, Atlantic City, N. J. Additional information may be obtained from society headquarters, 342 Madison Ave., New York 17, N. Y.

April 9-12—

Society of Automotive Engineers. National Aeronautic Meeting, Aeronautic Production Forum and Aircraft Engineering Display to be held at Hotel Statler, New York, N. Y. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

April 10-11—

American Society of Mechanical Engineers. Machine Design Division Conference to be held at the Bancroft Hotel, Worcester, Mass. Additional information may be obtained from society headquarters, 29 West 39th St., New York, N. Y.

April 10-12—

Metal Powder Association. Annual Meeting and Show to be held at Hotel Cleveland, Cleveland, O. Additional information may be obtained from society headquarters, 420 Lexington Ave., New York 17, N. Y.

April 11-13—

Institute of Radio Engineers. Seventh Region Technical Conference to be held at Hotel Utah, Salt Lake City, Utah. Additional information may be obtained from society headquarters, 1 East 79th St., New York, N. Y.

April 16-17—

American Society of Mechanical Engineers. Gas Turbine Power Division Conference to be held at Hotel Statler, Washington, D. C. Additional information may be obtained from society headquarters, 29 West 39th St., New York.

April 16-18—

American Institute of Electrical Engineers. Great Lakes District Meeting to be held at Fort Wayne, Ind. Additional information may be obtained from society headquarters, 33 West 39th St., New York.

April 18-19—

National Industrial Research Conference to be held at Hotel Sherman, Chicago, Ill. Sponsored by Armour Research Foundation of Illinois Institute of Technology. Joseph J. Kowal, Technology Center, Chicago 16, Ill., is conference secretary.

April 30-May 2—

Association of Iron & Steel Engineers. Spring Meeting to be held at the Lord Baltimore Hotel, Baltimore, Md. Additional information may be obtained from society headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

May 14-17—

Design Engineering Show and Conference to be held at Convention Hall, Philadelphia, Pa. Additional information may be obtained from Clapp & Poliak, 341 Madison Ave., New York 17, N. Y.

May 24-25—

Third Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsored by the Purdue School of Mechanical Engineering and MACHINE DESIGN. Additional information may be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

when a shim is

LAMINUM®

here are the advantages you get:

Shims stamped from LAMINUM® look and act like solid metal, but are made of laminations bonded together over their entire surfaces.

LAMINUM® comes in BRASS or STEEL (laminations .002" or .003") and in ALUMINUM (laminations .003")

REDUCED MACHINING COST:

You machine only to easy tolerances. The laminated shim is *adjustable*—you simply peel laminations of .002 inch or .003 inch with a penknife—to get exactly the spacing you need. You cut costs without sacrificing quality.

SIMPLIFIED USE:

Shims come to you in one "pack" for each application. They are precision-stamped to your exact specifications. No counting, no stacking, no miking. Gauge is always known. No dirt or grit can lodge between layers.

SPEEDED PRODUCTION:

Final fitting can be done right at the job. You don't have to take parts back and forth for further machining, grinding or filing. No special skill required. The laminations adjust spacing quickly, easily.

ADDED SERVICE FEATURE:

Throughout the life of the machines you produce, the simple removal of a shim lamination provides a unique adjustment for the take-up of wear. Original clearances can always be restored.

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FLASH! Now also made of **STAINLESS STEEL** in layers of .002" or .003"

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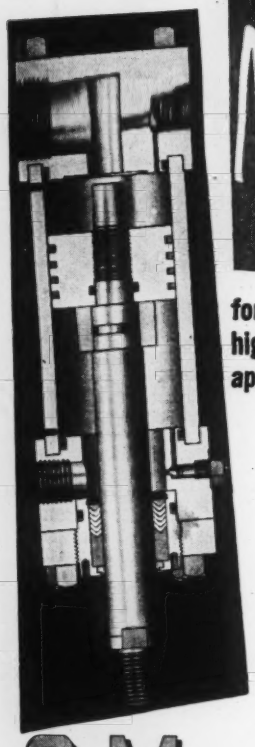

New

for high pressure applications

O-M Heavy Duty

HYDRAULIC CYLINDER

O-M's new hydraulic cylinder conservatively rated at 2000 PSI has been developed to provide maximum performance with minimum maintenance in heavy industrial applications.

Heavy walled seamless steel tubing micro-honed for minimum friction. Rolled steel heads recessed to confine tube, prevent breathing, leakage. Piston rods high tensile steel hard chrome plated. Long-lived, self-compensating rod gland packing ... removable without disassembling cylinder. *Available in bore sizes 1½" to 8" inclusive.*

Meets JIC standards

Send for FREE bulletin 105.

Shows complete engineering drawings, mounts, mounting brackets, performance data.

ORTMAN-MILLER MACHINE CO.
7 143rd Street, Hammond, Ind.
Please send FREE bulletin 105
Name_____ Position____
Company_____
Address_____
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—ITEM 173—

MEN OF MACHINES

Capt. C. S. Seabring, USN (ret.) has joined Alco Products Inc. as director of research and development. He will be located at Schenectady, N. Y., and will be responsible for certain aspects of nuclear power projects and gas turbine development.

Sylvania Electric Products Inc. recently appointed **Frank M. Thomas** manager of equipment development for its Electronics Div., located in Woburn, Mass. He is responsible for the mechanical, electrical and electronic development departments of the division, as well as the co-ordination of its mechanization program. Before his new appointment, Mr. Thomas was manager of equipment engineering for the company's Atomic Energy Div. at Hicksville, L. I., N. Y. He joined Sylvania in 1952 when this division was formed. Previously he was chief engineer of Fairchild Recording Equipment Corp., and before that was a member of the technical staff of Bell Telephone Laboratories.

Frank M. Thomas

An Advanced Electronic Data Laboratory has been established as a new facility of Consolidated Electrodynamics Corp., Pasadena, Calif. This laboratory, headed by **Robert L. Sink,** will undertake development of equipment in the magnetic-tape data processing field. Mr. Sink was assistant director of engineering for Consolidated.

Birdsboro Steel Foundry and Machine Co., Birdsboro, Pa., has announced the appointment of **Philip Finale** as chief engineer of the rolling mill division of Engineering Supervision Co., a Birdsboro subsidiary. Mr. Finale formerly was associated with the Loewy-Hydropress rolling mill division as chief engineer and had also been department engineer with Mesta Machine Co.

Philip Finale

Jack C. Boonshaft has been named consulting mechanical development engineer by CDC Control Services Inc., Hatboro, Pa. He

Announcing
FASTEX
DIVISION OF ILLINOIS TOOL WORKS
Now, bring your special stamping and plastic fastening problems to FASTEX, the new division of Illinois Tool Works. Here in one organization, you find a new service . . . the consolidation of the design and production of engineered stampings and plastic products formerly a part of the SHAKEPROOF Division. FASTEX is staffed with experienced engineers and skilled craftsmen, equipped with specialized facilities and organized to give you maximum flexibility and speed in design and production. FASTEX products are backed by the broad experience of the most famous name in fastenings ... SHAKEPROOF. Fastex Division, Illinois Tool Works, 186 Algonquin Road, Des Plaines, Illinois.
new ideas in metal stampings and molded plastic parts
Information about the new FASTEX Division is contained in a new FASTEX Bulletin. Send for it today.
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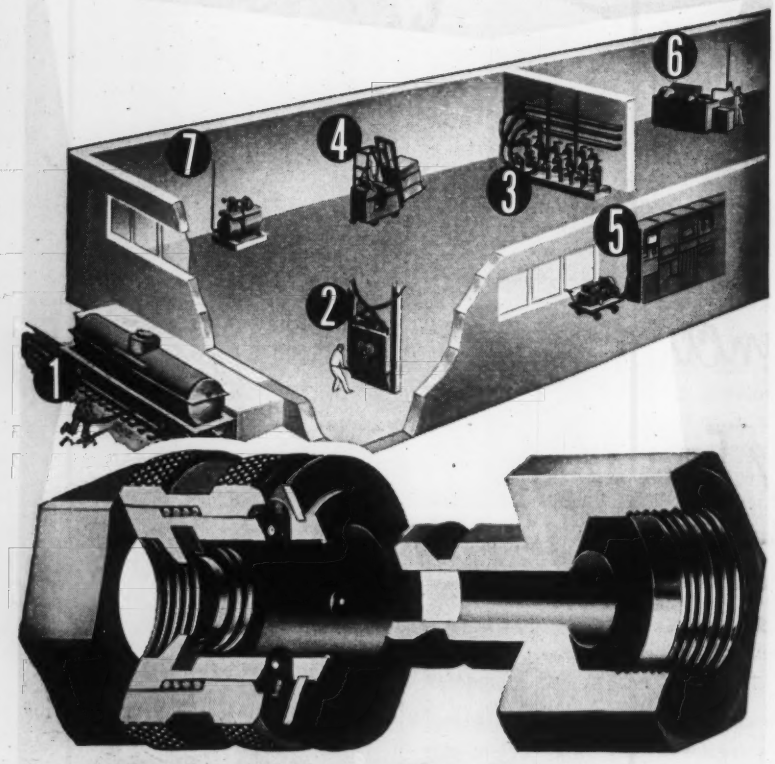
SHAKEPROOF
DIVISIONS OF ILLINOIS TOOL WORKS
World's Broadest Line of Mass-Assembly Fastenings



whatever the operation . . .

Titeflex Quick-Seal Couplings for fast, leakproof connections!

Everywhere in industrial operations, you find Titeflex Quick-Seal Couplings "making connections"! And what connections! *Absolutely* leakproof. Couple or uncouple in *one second*. Allow free flow of *any* material. Sizes ¼" to 12".

See drawing for typical uses. Then check your own plant for trouble spots where Quick-Seal Couplings can serve you *profitably*. For details . . . send coupon.

1. Tank Car Unloading
2. Furnace Doors
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6. Machine Cleaning
7. Air Lines for Tools

Titeflex

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508 Hendee Street, Springfield, Mass.
Send me your free Quick-Seal Couplings Catalog—don't obligate me.

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Firm_____

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Titeflex Quick-Seal Couplings • *Leakproof at all operating pressures, in every application*

Men of Machines

was formerly vice president in charge of engineering for Fischer & Porter Co. **David P. Goodwin,** previously chief engineer of Gemac Inc., is now electronic development engineer at CDC.

The Magnavox Co., Ft. Wayne, Ind., has appointed **Col. Loren E. Gaither,** Signal Corps, USA (ret.) as director of engineering of the Government and Industrial Div. Col. Gaither was director of the Evans Signal Laboratory of the Signal Corps Engineering Laboratories from 1951 to 1953.

The Navy Meritorious Public Service Citation, one of the highest honors which the U. S. Navy can confer on a civilian, has been presented to **Raymond A. Quadt,** director of research of the Hunter Douglas Corp., Riverside, Calif. Mr. Quadt was cited for his ". . . . outstanding contribution to the Navy in the field of research on cold forging the heat treatable aluminum alloys." An article written by Mr. Quadt, "Aluminum Cold Forgings," appeared in the June, 1954 issue of MACHINE DESIGN.

Vickers Inc., Waterbury, Conn., has appointed **Carl E. Gunther** as chief engineer of its Waterbury Tool Div. Mr. Gunther previously was director of research and engineering of the Fuller Brush Co.

Carl E. Gunther

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For More Information Circle Item Number on Yellow Card—page 19

Men of Machines

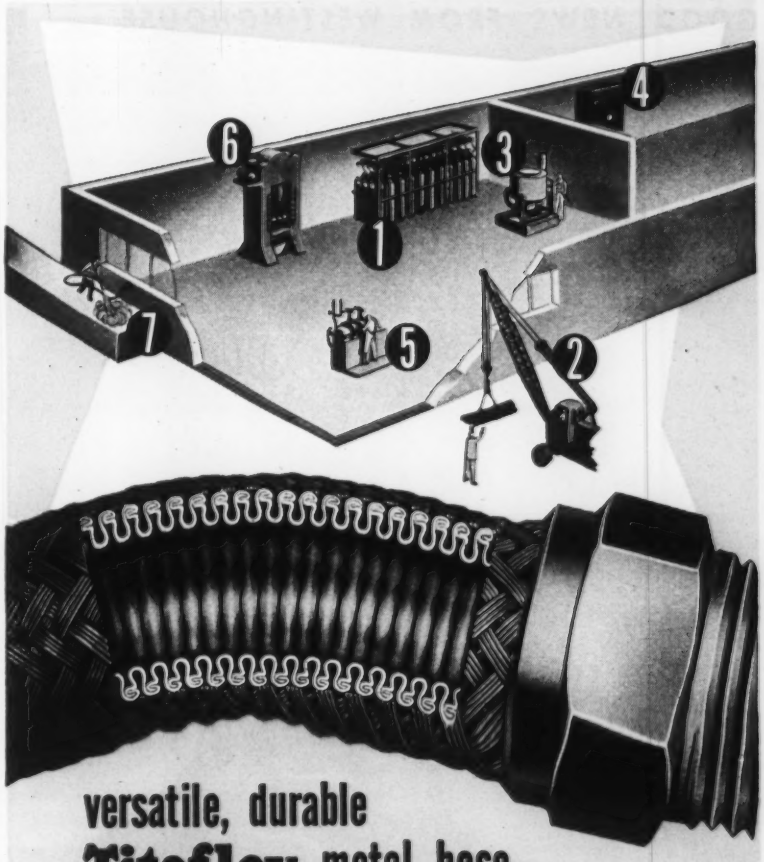
The Mechanical Div. of General Mills Inc., Minneapolis, has announced a staff reorganization which elevates **Cledo Brunetti** to the position of director of engineering, research and development, **Carl L. Kober** to associate director in charge of systems engineering, research and development, and **John E. Barkley** to associate director of research and development. Dr. Brunetti has been director of research and development; Dr. Kober, manager of systems analysis; and Dr. Barkley, manager of physics and chemistry research.

William R. Toeplitz, formerly vice president of engineering, was recently elected president of Bound Brook Oil-Less Bearing Co., Bound Brook, N. J. At the same time, **H. E. Thornton** was named chief engineer.

Liquidometer Corp., Long Island City, N. Y., has announced the appointment of **Louis M. Campani** as chief administrative engineer, **Julius V. DiFranco** as chief electrical engineer, and **P. Richard Rosenberg** as chief mechanical engineer.

Link Aviation Inc., Binghamton, N. Y., has appointed **George Friedl Jr.** to the new post of director of advanced planning. **William W. Wood Jr.,** formerly vice president in charge of engineering, succeeds Mr. Friedl as head of manufacturing. **John M. Hunt,** who previously headed the corporation's research and development departments, has been named manager of the engineering division, and **Monson H. Hayes Jr.** replaces Mr. Hunt as director of research and development.

Clary Corp., San Gabriel, Calif., has promoted two engineering supervisors to assistant chief engineers, to head new development programs. **Kenneth F. Oldenburg** will continue to be in charge of the electronic and data-processing equipment department, and **Milton Scozzafava,** of the business machines department.



versatile, durable
Titeflex metal hose . . .
for every type of processing operation

Can take grueling punishment from corrosive fluids, high temperatures, excessive vibration and pressures . . . or from any combination of these industrial *spoilers*. All-metal construction. Wide range of sizes. Braided or unbraided. Choice of alloys and fittings to meet *every* need.

Titeflex Metal Hose finds many important jobs *everywhere*. Investigate your processing operations now and see where Titeflex Flexible Metal Hose can work for you. Send in coupon for important additional information *today*.

1. Fire Extinguisher
2. Air Control Lines
3. Cleaning Vats
4. Air Conditioning Units
5. Milling Machine
6. Hydraulic Press—Lubricating Lines
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508 Hendee Street, Springfield, Mass.
Send me your free Titeflex Flexible Hose Catalog without obligating me.

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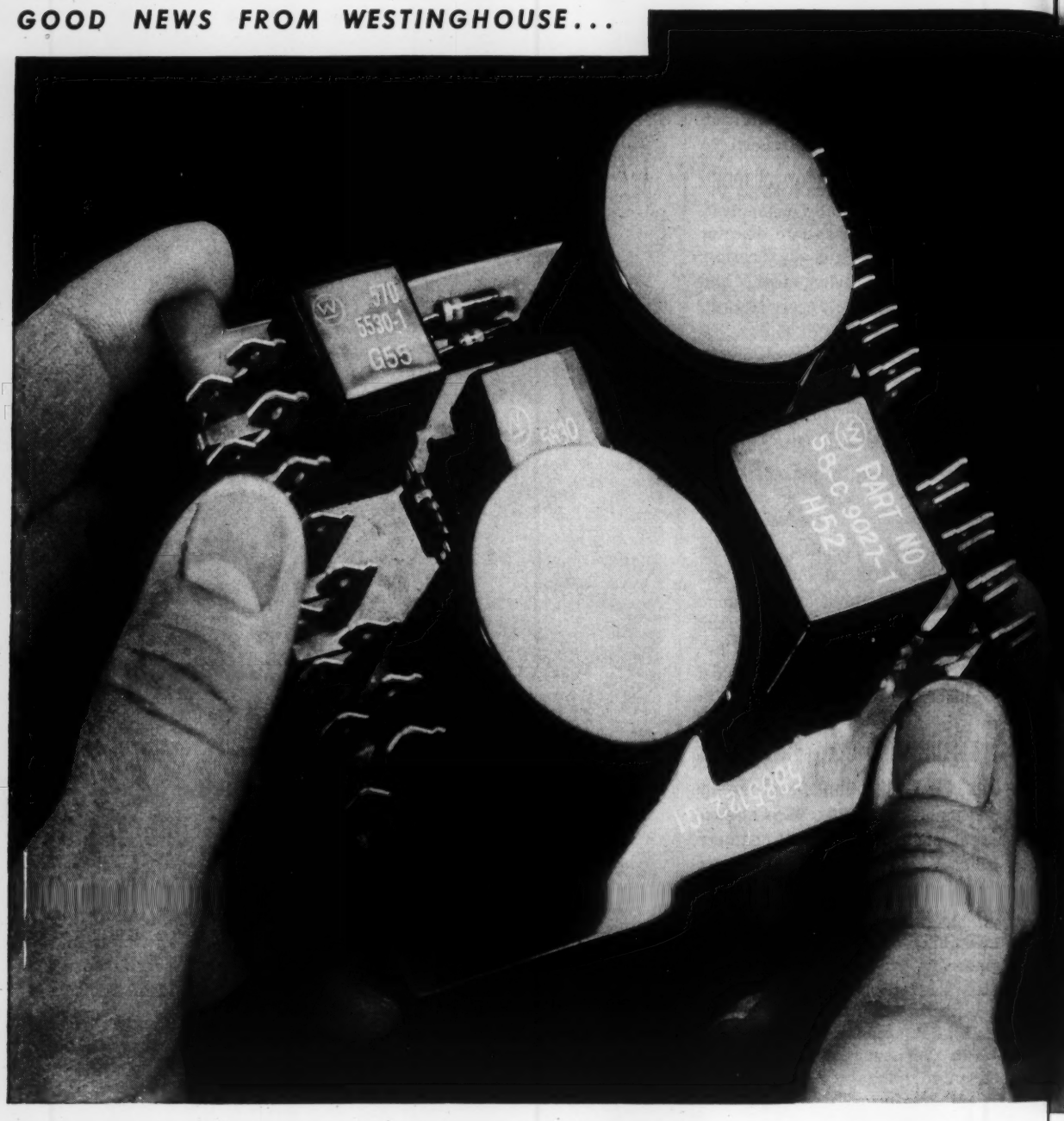
TITEFLEX FLEXIBLE METAL HOSE licks corrosion temperature vibration pressure in all industrial operations

—ITEM 176—

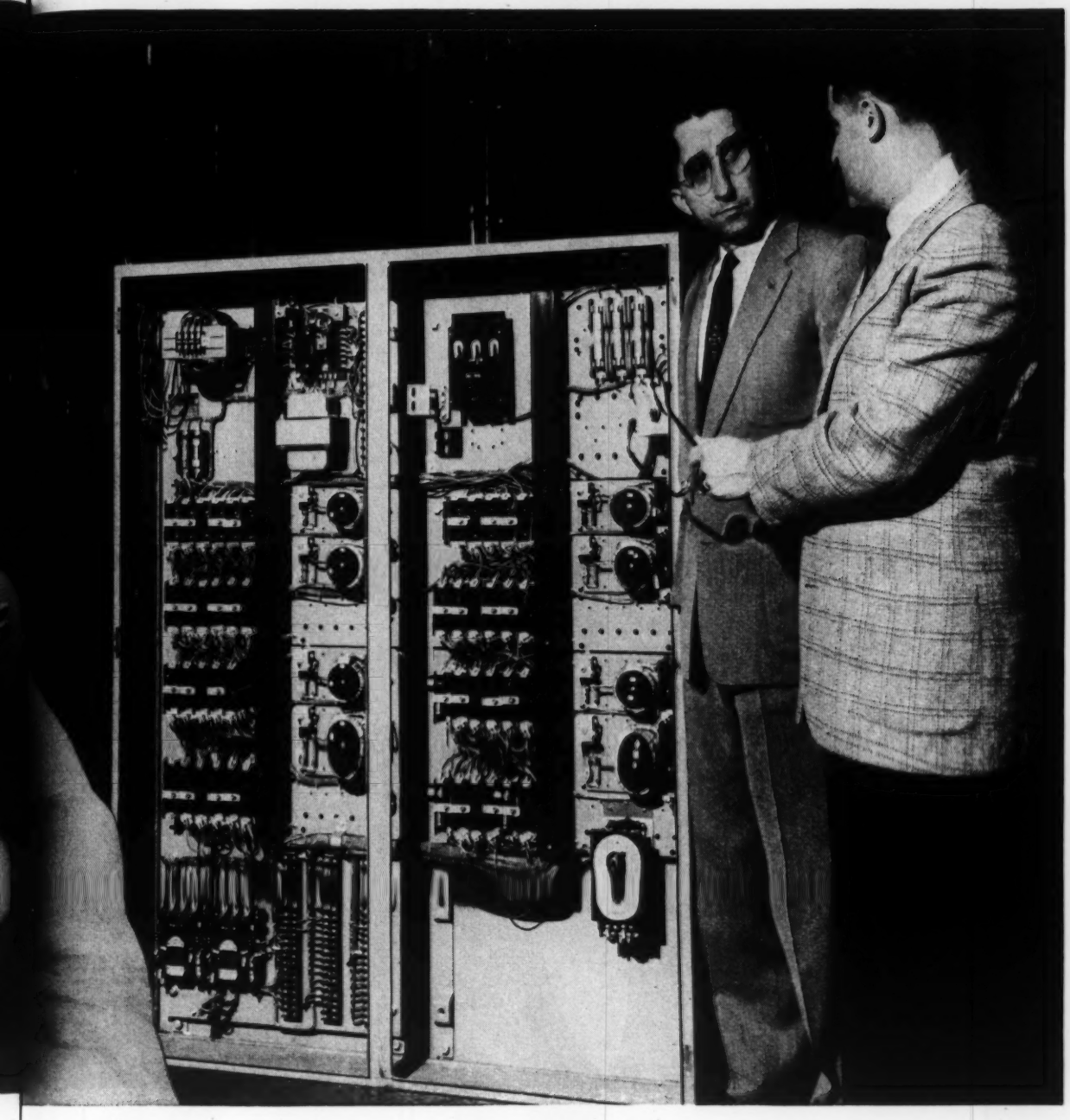
GOOD NEWS FROM WESTINGHOUSE...



THIS IS

CYPAK*

the most revolutionary industrial control advance in 25 years



Just two years ago, production and control engineers alike dreamed of the possibilities of a relay with no moving parts. A reality today, Westinghouse CYPAK introduces static control from units that fit the palm of your hand. CYPAK control has no moving parts to wear, corrode, jam or otherwise cause failure. In addition, CYPAK refines the relay art through making use of basic logic functions.

The result—static control with life at least 15 times that of conventional relays. While twenty million open-close cycles is usually the maximum life of a mechanical relay, CYPAK systems can handle that many cycles in days without a trace of fatigue.

Besides eliminating maintenance and down time, CYPAK opens new opportunities for broader, more complex control. Look into these advantages of CYPAK by calling your Westinghouse sales engineer. J-01002

* Trade-Mark

Write today for your free copy of *The Whys and Wherefores of* CYPAK, Booklet B-6584. Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pa.

YOU CAN BE SURE...IF IT'S Westinghouse

—ITEM 177—

ROCKFORD

New MORLIFE* CLUTCHES and CLUTCH PLATES Give—

MORE Clutch Life (400% MORE)
MORE Torque Capacity (100% MORE)
MORE Heat Resistance (50% MORE)

These *new* ROCKFORD Clutches and Clutch Plates have been developed by ROCKFORD Clutch Engineers to take full advantage of recently discovered facing material. Actual field tests on heavy duty equipment have resulted in adoption of MORLIFE

*TRADE MARK

"MORLIFE clutch has gone 851 hours without slipping or adjustment."

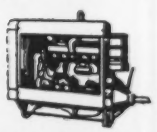
"MORLIFE clutch going strong after 1695 hours, working in sand."

"MORLIFE clutches last 930 hours longer, without adjustment."

"MORLIFE clutch needs adjustment once a month, instead of daily."

"MORLIFE requires lighter handle pull and one tenth the adjustments."

"MORLIFE requires lighter handle pull and one tenth the adjustments." "MORLIFE pulls harder and lasts six to ten times longer."



"Won't buy a unit that isn't equipped with Durable MORLIFE clutch."

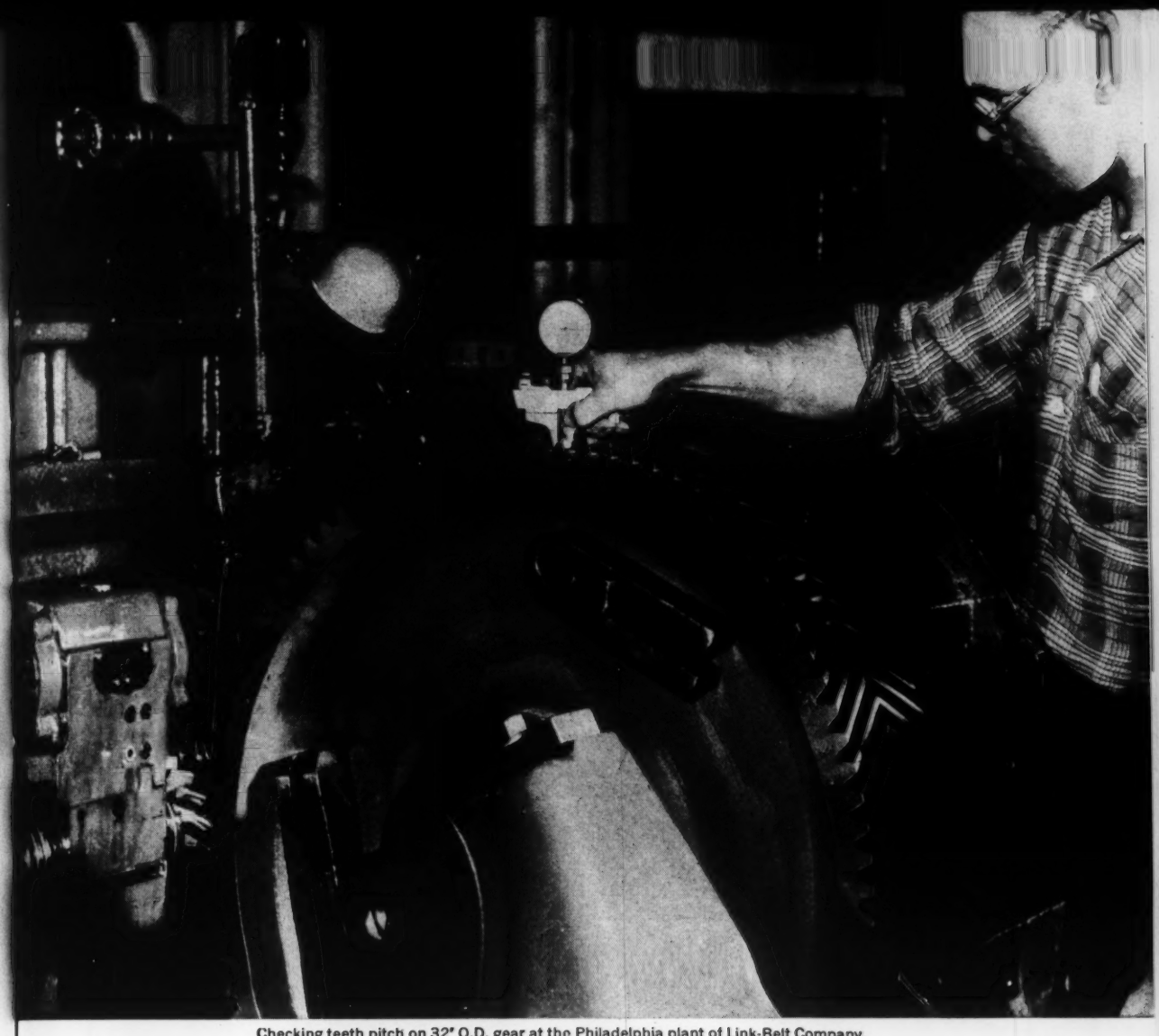
B. W. ENGINEERING MAKES IT WORK
BW
B. W. PRODUCTION MAKES IT AVAILABLE

clutches by builders of tractors, earth movers, graders, shovels, cranes, trucks, oil field equipment and power units. For information how these *new* Rockford MORLIFE Clutches will Improve the operation and increase on-the-job hours of heavy duty machines, write Department E.

ROCKFORD Clutch Division BORG-WARNER

311 Catherine Street, Rockford, Illinois, U.S.A.

CLUTCHES



Checking teeth pitch on 32" O.D. gear at the Philadelphia plant of Link-Belt Company.

speed up machining, extend cutter life with Standard Steel forged gear blanks

By switching to Standard Steel forged blanks for the helical and herringbone gears used in their enclosed drive units, the Philadelphia plant of Link-Belt Company has speeded up machining time and lengthened cutter life substantially. That's because:

- Dimensional tolerances are closer, so all gear blanks of the same size can be machined on a single setup.
- Standard Steel forged blanks have no blow holes, porosity or non-metallic inclusions, so finish turning, facing, boring and hobbing can be done faster.
- High speed cutters last much longer because these forgings have a more uniform internal structure.

Link-Belt's experience in reducing costs is typical of hundreds of other manufacturers. When you specify Standard Steel forgings, you get a product that is quality-controlled from start to finish. We produce our own acid open hearth steel, heat treating and tempering it carefully. Finished forgings are carefully inspected and checked to assure meeting customer specifications.

In addition to gear blanks, Standard Steel can furnish you with rings, flanges, shafts, wheels and special shapes—and furnish them *fast*. Next time you need forgings, get our quotation first. For a copy of our new bulletin, write us at Burnham, Pennsylvania.

BALDWIN · BLH · LIMA-HAMILTON

STANDARD STEEL WORKS DIVISION
BALDWIN-LIMA-HAMILTON
DIVISIONS: Austin-Western • Eddystone • Lima Electronics & Instrumentation • Hamilton • Pelton • Loewy-Hydropress • Madsen

LINK-BELT announces MOTOGEARS and

MOTOGEARS

for bracket mounting NEMA foot-type motors of any manufacture . . . widest application flexibility . . . up to 60 hp

ABILITY TO ACCOMMODATE WIDE RANGE OF MOTORS solves emergencies, minimizes downtime.

EASY MOTOR REPLACEMENT is accomplished by removing four bolts and separating coupling—oil drainage is unnecessary. Motor bracket assures rapid realignment.

RIGIDITY of high speed shaft and pinion is provided by straddle-mounting—important in coping with shock, reversing and heavy loads.

STURDY BRACKET MOUNT is securely bolted to drive housing and provides rigid mounting for motor.

★ *Years-ahead design* — to harmonize with modern NEMA motors

★ *Stamina for the years ahead* — combining utmost compactness and highest efficiency for heavy-duty service

line of New, COMPACT GEARMOTORS...

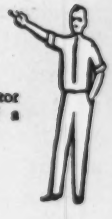
GEARMOTORS

the ultimate in compactness . . . with flange-mounted NEMA motors . . . up to 30 hp

UTMOST COMPACTNESS is provided by flanged connection of motor to gear drive.

ONE-PIECE HOUSING cuts maintenance, offers added strength and assures oil-tight, quiet operation.

BUILT-IN ALIGNMENT of motor is provided through use of a rabbet-fit motor flange.



NEVER before has a speed reduction line offered this combination of features: *oil-tight design* having a minimum number of openings, each protected by an effective oil seal; *quiet operation* resulting from precision machining and noise-absorbing, cast iron housing; *standardization* with only one low-speed gear set per drive size; *compactness* derived from a unique gear arrangement; *integral backstop* with positive-locking action, which may be installed at any time. Learn all about these advanced new drives—ask your Link-Belt office or authorized stock-carrying distributor for Book 2447.

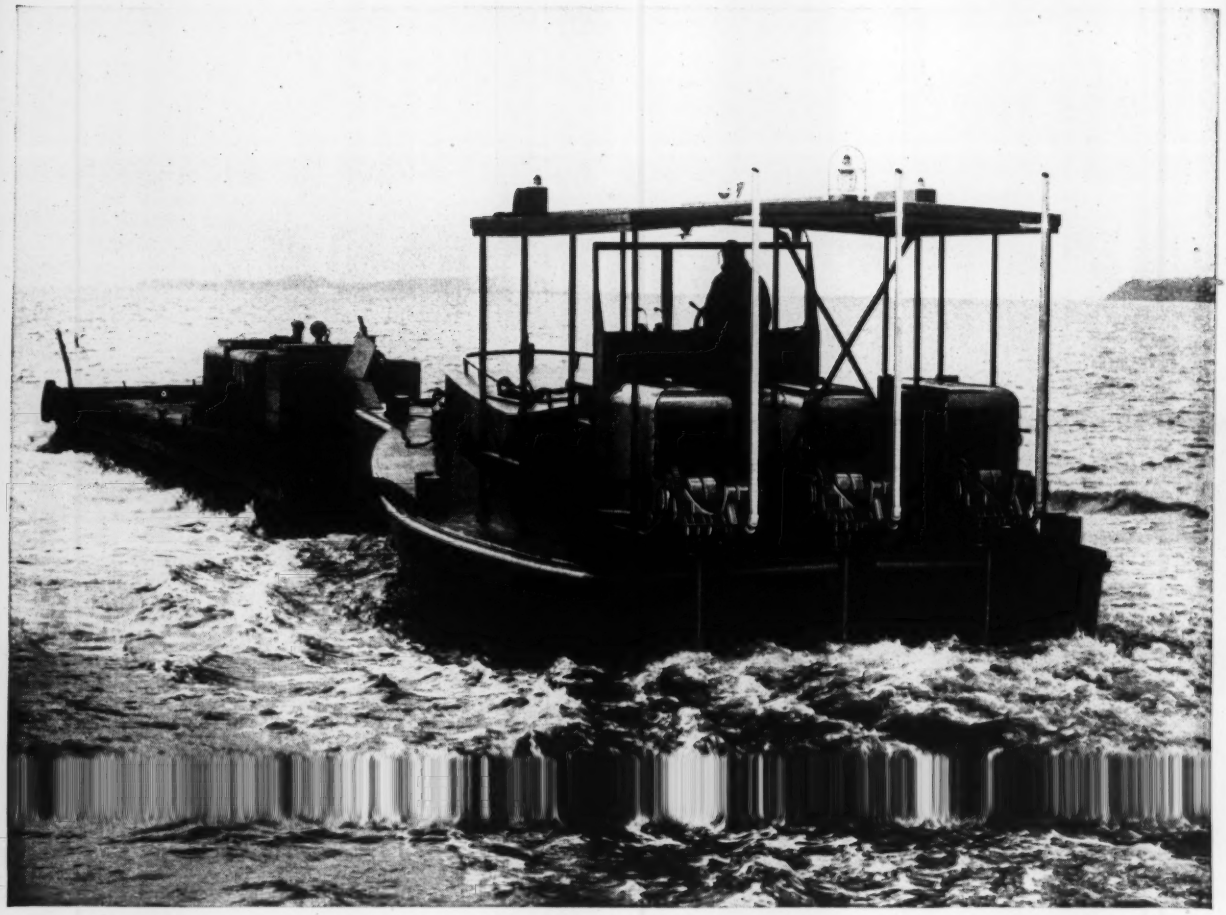
LINK-BELT

ENCLOSED DRIVES

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1,

To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,957

—ITEM 180—



The Harbormaster, is a king-size power unit designed for rough use aboard barges, dredges and work boats. An Airco Oxygraph is a key production tool used to quickly and economically flame cut over 25 of its component parts from heavy steel. Airco electrodes—the Easyarc 12—are depended upon for the utmost in strength and welding speed.

Airco Electrodes & Cutting Machines

satisfy design and strength needs for unique outboard engine

The Mathewson Machine Works Inc., have been manufacturers of marine equipment since 1885. They find in building the Harbormaster that the extensive use of Airco electrodes, cutting equipment and industrial gases combine to provide them with the greatest degree of production flexibility and the widest margin of economy.

From planning to production you can rely on assistance—and completely unbiased recommendations—from Airco Technical men. For Airco is the leading supplier—manufacturer of all kinds and every type of welding and flame cutting processes, their controls, supplies and accessories.

Write to Airco for free literature on electrodes, cutting apparatus, and cutting machines.

WELDING SHOW — VISIT OUR BOOTH

welding
AT THE FRONTIERS OF PROGRESS YOU'LL FIND . . .

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AIR REDUCTION SALES COMPANY

A division of Air Reduction Company, Incorporated, New York 17, N. Y.

On the west coast — Air Reduction Pacific Company

Internationally — Airco Company International

In Cuba — Cuban Air Products Corporation

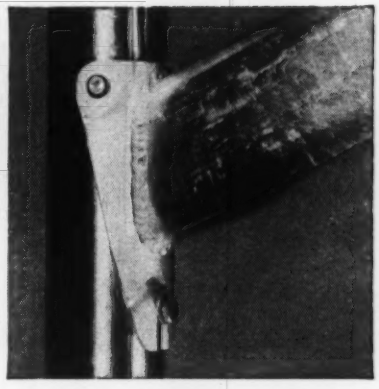
In Canada — Air Reduction Canada Limited

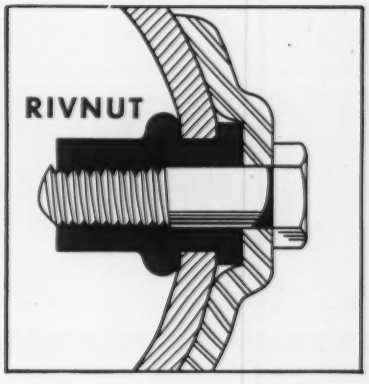
Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO** — industrial gases, welding and cutting equipment, and acetylenic chemicals • **PURECO** — carbon dioxide, liquid-solid ("DRY-ICE") • **OHIO** — medical gases and hospital equipment • **NATIONAL CARBIDE** — pipeline acetylene and calcium carbide • **COLTON** — polyvinyl acetates, alcohols, and other synthetic resins.

—ITEM 181—

For More Information Circle Item Number on Yellow Card—page 19

3 B. F. Goodrich RIVNUTS replace 4 nuts—cut assembly costs 50%





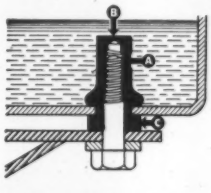
B. F. GOODRICH RIVNUTS provide a firm, accurate nut plate in one, quick operation. Nuts, welding, tapping and clinching are eliminated.

In the street light application illustrated, it used to take two men to fasten the arm bracket to the pole with nuts and bolts. Then Pfaff & Kendall, world's largest supplier of tubular aluminum poles, redesigned the unit to use Rivnuts. Now one man does the job in the same amount of time.

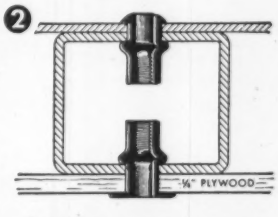
At the factory, (top left) a worker installs the Rivnuts in the aluminum pole in seconds. In the field, the assembler slips the slotted part of the arm bracket over a bolt screwed halfway into the lower Rivnut. Resting the arm on this bolt, he screws the top two in place; tightens all of them (middle photograph). Tests show that the pole or arm bracket will fail before the Rivnuts.

If you're looking for a fastener that can help you cut costs, get more information on Rivnuts or engineering help by writing: The B. F. Goodrich Company, Dept. MD-36, Akron, Ohio.

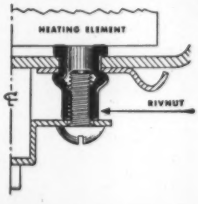
If you have fastening jobs like these, get B. F. Goodrich RIVNUTS



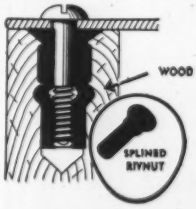
ELIMINATES BRAZING! Rivnuts with closed end (B) are installed in one-tenth the time it took to braze nut plates on oil reservoir tanks. Leaking, warping and thread cleaning are eliminated (A). Spacer head (C) positions tank.



FASTENS PLYWOOD TO STEEL! Easier to install than wood or self-tapping screws, Rivnuts fasten plywood walls to tubular steel sections in trailers. No wood filler needed.



ELIMINATES REINFORCING PLATE! In assembly of vaporizers, Rivnuts do away with reinforcing plate, don't turn under torque, hold flange securely without bending. Result: less assembly time, fewer parts, better product.



GIVES 6 CLEAN THREADS IN WOOD! Special Rivnut for solid fastening in wood eliminates wood screws, provides 6 metal threads for attachment bolt. Bulge formed by upsetting holds Rivnut fast. Splined shaft keeps it from turning.

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten TO and fasten WITH. Explains construction, simplicity of installation. Get your free copy today by writing to: The B. F. Goodrich Company, Department MD-36, Akron, Ohio.

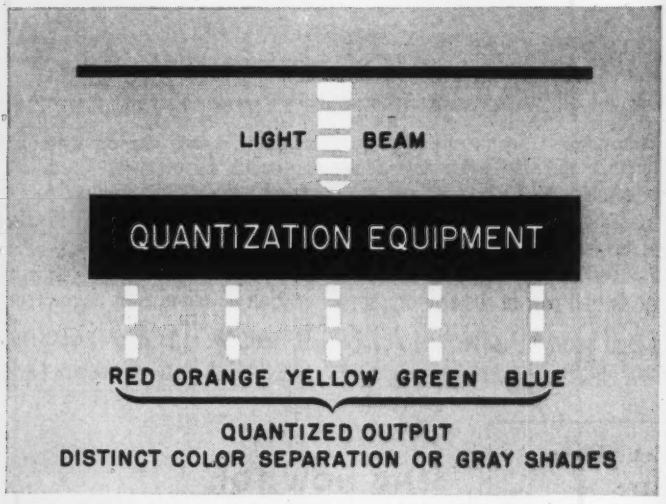
B.F.Goodrich RIVNUT

The only one-piece blind rivet with threads

—ITEM 182—

FORD INSTRUMENT
QUANTIZES LIGHT

Colored lines or spots on a piece of paper can become a means of conveying information – Rorschach charts, impressionist paintings and survey maps are all visual message carriers. Ford Instrument engineers found it necessary to translate such color information into electrical or mechanical quantities, (quantization) with less distortion than is inherent in the usual photographic techniques. Such quantities can in turn be used as signals that actuate computers, make offset plates, and generally put to use the information implied by the difference between the colors or the distribution of the colors.



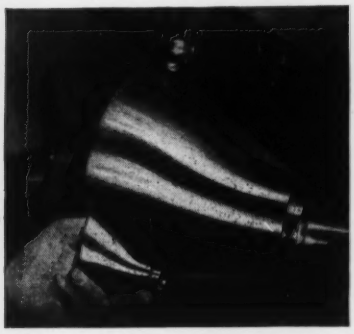
The quantization performed by Ford is not restricted to color alone. For example, a black and white photograph represents an aggregate of light and dark areas of varying shades, and this display must frequently be converted into continuous or discrete electrical quantities for various purposes and uses. Ford engineers recently developed equipment which can quantize and record the various degrees of color, or gray areas in photographic negatives, and to correlate this information into usable data. This equipment was developed for a classified project – the equipment is unavailable for general use – however the technical know-how gained by Ford – combined with Ford's superior production and engineering facilities – is available in the creation of light quantizing equipment for you.

Light quantizing is but one of the many facets of Ford Instrument design and development. For more information about Ford's products, services and facilities, write for an illustrated folder. Ford engineers will be happy to discuss your problems of control with you.

88

FORD INSTRUMENT COMPANY
DIVISION OF SPERRY RAND CORPORATION
31-10 Thomson Avenue, Long Island City 1, New York
Beverly Hills, Cal. • Dayton, Ohio

Ford's capabilities are among the finest in the country



Three dimensional cams are used in elaborate computing devices to characterize shell ballistics, magnetic variation, or to solve some basic mathematical function. Precision in 3-D cams is of vital importance. Ford Instrument designed and built a unique machine that can produce extremely accurate cams from a skillfully made master. As many as two thousand data points are end-milled to set precisely the contours of the handcut masters.

Equipment used for defense must undergo rigorous tests for accuracy and dependability in combat. At Ford, environmental testing laboratories reproduce extremes of desert or arctic battle, shock of warship broadside, salt fogs and heavy seas. When flaws have been detected and corrected, equipment is okayed for volume production and use throughout the armed services.

Typical of Ford Instrument's 40 years of experience in precision control is its work in the field of nuclear power. The Company, for example, is building the control rod drive mechanism for the Seawolf, second atomic submarine. Reactor designs, sensing mechanisms, control equipment and systems, nuclear calculations, and other specialized equipment and abilities are offered by the Company to this expanding industry.

—ITEM 183—
For More Information Circle Item Number on Yellow Card—page 19

Checking contact and backlash of a production gear set at the De Laval Steam Turbine Company.

How to Save in Selecting Worm Gear Sets

By JAMES E. GUTZWILLER, *Assistant Chief Engineer, Worm Gearing Department*
De Laval Steam Turbine Company

Worm gear sets have four major advantages: compactness, easy maintenance, interchangeable components, and high shock-load capacity. The user can realize maximum benefits from these advantages and reduce costs by acquiring some background information on the characteristics of worm gearing. Here are a few points to consider.

Standard Components. Find out what standard components are available before proceeding with design. De Laval stock parts include worms, gears, bearing housings and end covers. By selecting from these, the user may sharply reduce the cost of the finished gear set.

HOBBING MACHINE — Tangential feed gives uniform teeth of precise dimensions. This is accepted as the most satisfactory method for producing close tolerance worm gearing.

The hob, for example, must match the pitch diameter, pitch, lead and tooth form of the worm. Designers who are familiar with standard hobs can design a worm accordingly and save the expense and delay of obtaining a special hob.

A Note on Assembly. The worm, having threads which are continuous in form, is not critical in regard to endwise location. The gear, however, must be precisely positioned in an axial position. Accumulation of tolerances on the dimensions of housings, shafts, bearings and gears makes it impractical, in most cases, to control the location of the gear by accuracy of machining alone.

Shrouding. Heat developed in the gearing will be more freely dissipated through a comparatively open housing. Close shrouding is permissible only when intermittent operation is the rule.

Helpful Manual on Worm Gear Sets

For information on how to select, install and maintain worm gear sets, send for this helpful manual. It contains useful data on gearing and includes examples of specific selection problems with their solutions. Write on your business letterhead to the De Laval Steam Turbine Company, 858 Nottingham Way, Trenton 2, N. J. for Catalog 5000.

AL Stainless Steels
for the Process Industries

VARIOUS TYPES—Generally speaking, stainless steels are divided into three groups: chromium, chromium nickel, and chromium-manganese-low nickel steels. Their corrosion resistance, hardenability, tensile strength, etc., varies with the proportion of chromium, nickel and other alloying elements each type contains.

The chromium stainless grades are divided into two types: martensitic steels, which are hardenable; and ferritic non-hardenable steels. Both types are magnetic. The chromium nickel and chromium-manganese-low nickel stainless grades are austenitic steels, hardenable only by coldworking, and are non-magnetic.

The principal chromium stainless steels of chemical industry significance are Types 410, 431 and 440A martensitic grades, and Types 405, 430, 442 and 446 ferritic steels. Chromium nickel austenitic steels of principal importance are Types 302, 304, 316, 317, 347, 309 and 310. In the more recently developed chromium-manganese-low nickel austenitic group, Type 202 has physical and mechanical properties closely approximating those of Type 302—with the advantage of much lower nickel content and more ready availability in times of nickel shortage.

PRINCIPAL GRADES—Industry has called for quite an extensive range of chemical and physical properties in stainless steels. To meet these requirements, types have been developed which are best suited for a particular application: such as Types 316 and 317 for extra corrosion resistance, Types 309 and 310 for extra high temperature service, etc. Knowledge of these stainless steel qualities is essential for engineers and designers to create a product that will best do the work for which it was intended. Complete data on AL Stainless Steels is available in the various publications listed below.

Of all the stainless steels, the grades most used in the chemical and allied industries are Types 304, 316, 317 and 347 chromium nickel steels. The first three grades are also available in extra low carbon varieties to meet extreme conditions of fabrication or service which might carry the threat of intergranular corrosion. Designated Types 304L, 316L and 317L, these low carbon stainless steels are practically immune to carbide precipitation in the as-welded condition. Like Type 347, they permit the field-welding and stress-relieving of material of any thickness, for example, without the hazard of intergranular corrosion.

REGULARLY SUPPLIED FORMS—Allegheny Ludlum Steel Corporation is in position to furnish the various grades of stainless steel in all of the commercial forms required by fabricators of these metals. These include:

- Plates, including formed heads
- Sheets, either coiled or straight cut lengths
- Strip, either coiled or straight cut lengths
- Bars, rounds . . . flats . . . hexagons . . . octagons . . . squares or special shapes
- Billets, for forging or upsetting
- Angles
- Wire
- Tubing, seamless or welded
- Castings and smooth-hammered Forgings
- Extrusions
- Clad stainless

Information as to size ranges and mill tolerances are available in literature devoted to detailed discussions of AL Stainless Steels.

SPECIAL REQUIREMENTS—When selecting a grade of corrosion and heat resisting steel for a given application, it should always be borne in mind that laboratory tests, however carefully performed, can be expected at best to be only indicative of field performance. Variations in actual service conditions are so wide that a special study of the case at hand may be necessary at times. To that end, Allegheny Ludlum engineers and technical men are available for consultation on unusual problems involving stainless applications.

FABRICATION—AL Stainless Steels may be easily fabricated by any of the usual processes—welding, drawing, blanking, machining, spinning, forging, riveting, shearing, soldering, etc. In some instances, however, care must be exercised in handling of the material to preserve its corrosion or heat resisting properties. No one should undertake to fabricate any of the stainless steels without a full understanding of these handling procedures. Proper processing is fully discussed in Allegheny Ludlum literature—available on request.

RESISTANCE TO ATTACK—There is a wide range of conditions under which AL Stainless Steels operate in resisting corrosive attack at normal and elevated temperatures. Detailed information regarding their resistance to various media, heat resistance and strength will be sent upon request. See the publication list below.

STAINLESS CLAD STEEL—Allegheny Ludlum Stainless Clad is available commercially in the following commodities:

- Double Clad—Stainless both surfaces with carbon steel core. In plates, sheets and strip.
- Single Clad—Stainless one side only; plates only 3/16" and heavier.

Special clad materials on application.

PUBLICATIONS AVAILABLE

The following list of technical and service literature is freely available on request; just ask for the bulletins which contain the type of information you need.

Blue Sheets—An individual Blue Sheet, containing certified laboratory data on physical and chemical properties, etc. is available on each grade of AL Stainless Steel.

Fabrication of Stainless Steels—Contains valuable data for your shop men on various methods of handling, forming and finishing stainless steel.

AL Stainless Steel in Chemical Processing—36 pages on various applications, advantages, etc. of stainless in the chemical industry.

Stainless Steel Handbook—A case-bound book of 124 pages, containing complete data leading to the proper selection and fabrication, etc. of the correct grade of stainless for each application.

● Write to *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.*

ADDRESS DEPT. NO. MD-75

WAD 5787

For Stainless Steel in ALL Forms—call

Allegheny Ludlum

AL STAINLESS STEEL ®

Warehouse stocks carried by all Ryerson Steel plants

MONEY-SAVING MAGIC IN THIS "HEEL AND TOE"

This Tinnerman fastener is modeled after your foot . . . there's a heel and toe . . . it slides easily into the holes punched in the metal, fiber, or plastic, even as your foot slides into a shoe. But it is much easier to put on than to take off!

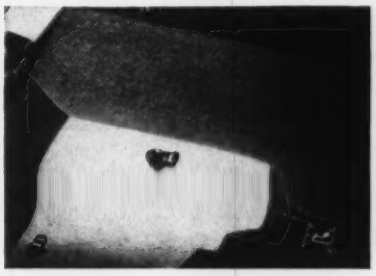
The primary function of this SPEED NUT fastening principle is to provide a fast, easy-to-apply, low-cost, self-retaining fastener. Its snap-on attachment feature requires little skill and no welding or staking. Yet it assures positive retention for center panel or blind locations.

Tinnerman "heel-and-toe" fasteners can also have a wide variety of fastening features. The self-retaining heel-and-toe can be combined with the famous Tinnerman SPEED NUT impression. Or with a speedy cable clip . . . or a spring catch . . . a molding clip . . . a wire retainer . . . almost any fastening idea you require.

Tinnerman sales engineers are ready to make a SPEED NUT Analysis of your fastening requirements. Or you can write to us for details and engineering data. *Tinnerman Products, Inc., Box 6688, Dept. 12, Cleveland 1, Ohio.*

TINNERMAN
Speed Nuts
FASTEST THING IN FASTENINGS®

On dictating equipment, this SPEED CLIP® holds wires safely away from moving parts.



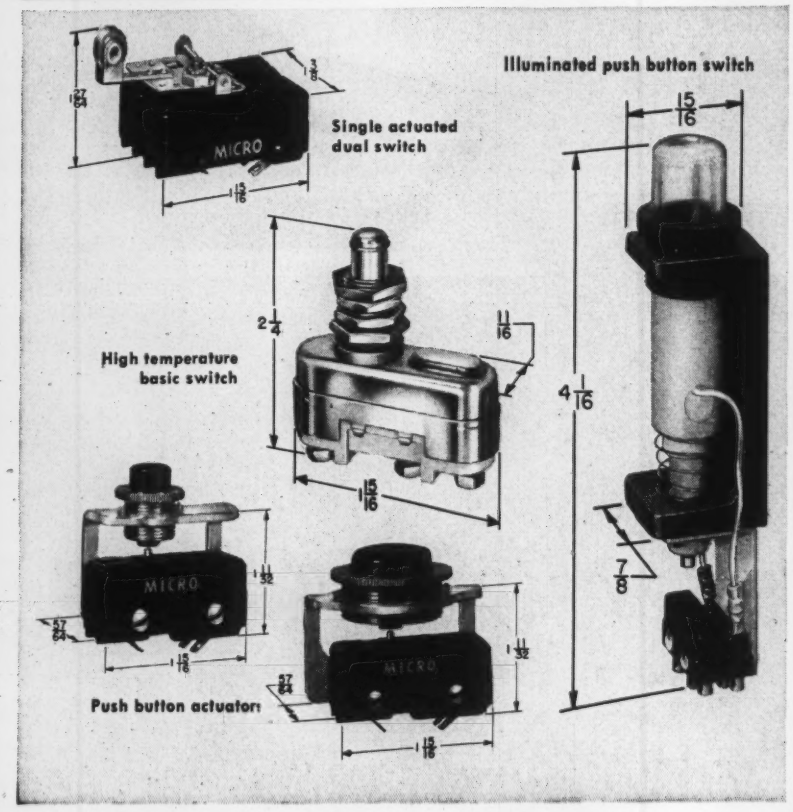
SPEED CLIPS secure molding on plastic sign, help manufacturer gain 48% assembly saving.

Assembly of TV tuning coil to chassis and servicing simplified with special SPEED CLIP.

—ITEM 185—

MICRO precision switches

...THEIR USE IS A PRINCIPLE OF GOOD DESIGN



A continuous flow of Precision Switch developments anticipates designers' needs

Function of MICRO SWITCH Engineering, both at the factory and in the field, is to supply the precision switch which most exactly meets the design requirement.

Shown here are just a few recent MICRO SWITCH developments that designers have found useful in a wide variety of applications. Write to any branch office or to Freeport, Illinois for more detailed information.

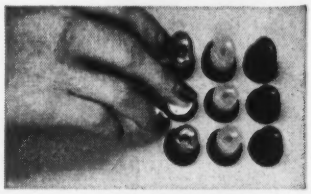
The Single Actuated Dual Switch consists of two basic switching units operated by a roller lever actuator. The operating point of one of the basic switches is field adjustable so either simultaneous actuation or a definite sequence of operations is possible.

The Illuminated Push Button Switch is a low force, high pre-travel switch with an indicating light as an integral part of the push button. The high pre-travel permits movement of the button before the contacts snap over. This switch is designed for use in electronic, aircraft, mobile, marine, railway and other low voltage a-c or d-c applications.

The High Temperature Basic Switch is a precision snap-action switch which will operate satisfactorily in a temperature range of from −50° to plus 1000° F. It is useful in such industrial applications as found in distilleries, foundries, vulcanizing plants and other industries which require high temperature components.

Push Button Actuators are of a new series available to designers of electrical computers and other types of commercial and industrial devices which require reliable panel-mounted, manually-operated switches. They are available with ½" or 1" buttons and combine attractive appearance and extremely long life with an exceptionally good actuation "feel".

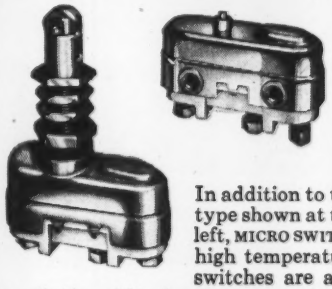
Manufacture of precision switches is not a side line with MICRO SWITCH. It is our entire *business*. That is why industrial designers come to us more and more each year with switch problems of amazingly diverse types. MICRO SWITCH branches are conveniently located to serve you.



Illuminated Push Button Switches allow mounting on one inch centers

MICRO SWITCH Illuminated Push Button Switches are outstanding for ease of operation, high pre-travel, compact design (which permits mounting on one inch centers), smooth appearance and easy-to-see pilot light. Switches are provided with sockets for a single contact miniature bayonet lamp. Removable translucent push buttons are available in clear, red, or frosted white.

High Temperature Switch comes in three actuator types



In addition to the type shown at the left, MICRO SWITCH high temperature switches are also available with pin plunger actuators for use where space is limited and small operation motion is available and roller plunger actuators for applications where cam or slide action is required.

Visit Booths 356-358 IRE SHOW

Kingsbridge Armory

NEW YORK

MARCH 19-22

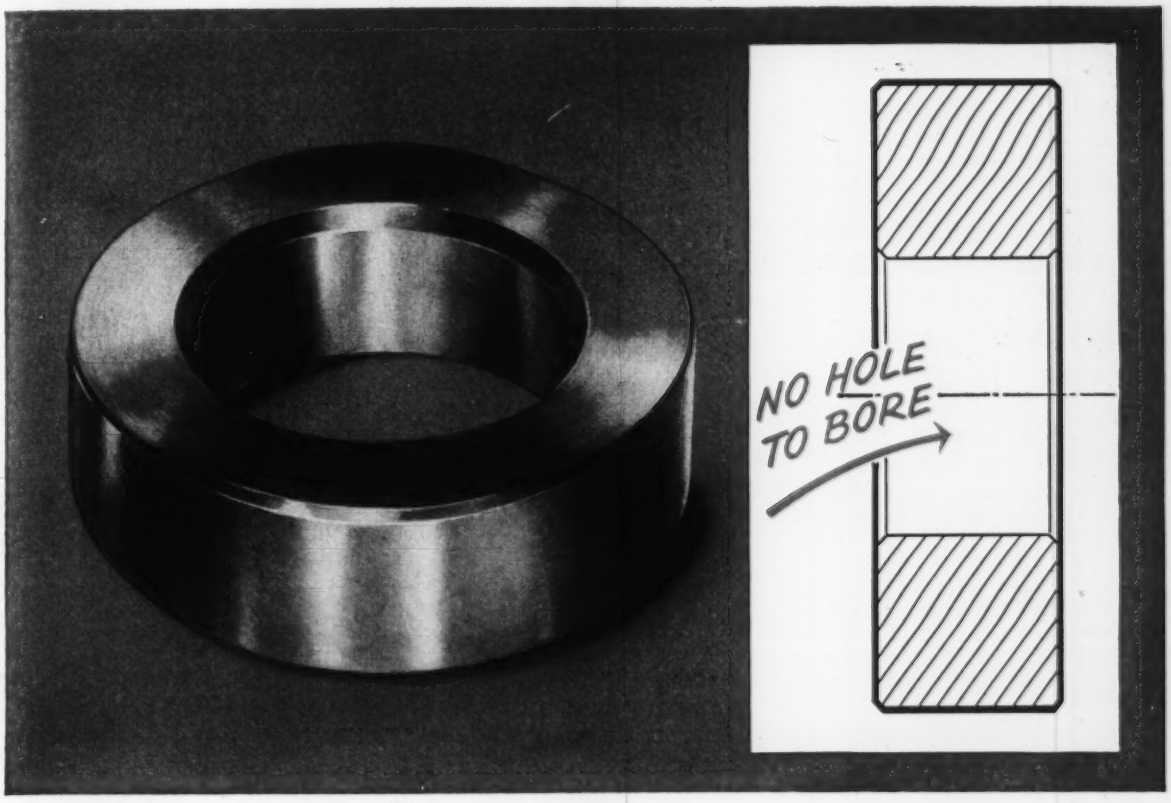
MICRO SWITCH Engineering Service is available to help you select the exact switch to meet your design problem. Call the MICRO SWITCH branch nearest you.

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

—ITEM 186—



Steps up gear blank production

300% by switching from bar stock to TIMKEN® steel tubing

AN engine manufacturer felt that his gear blanks were costing him too much to make. The center hole had to be bored out of solid bar stock. It took a whole hour to turn out 29 blanks. And a lot of steel was wasted in the process.

So the manufacturer discussed his problem with metallurgists of the Timken Company, experts in fine alloy steel. After study they recommended a change in production methods together with a switch to Timken® seamless steel tubing in place of bar stock.

With Timken seamless steel tubing, the center hole is already there. It doesn't have to be bored out. Finish boring was the engine maker's first production step. And with Timken steel tubing his gear blanks are now being turned out at 120 to 130 an hour—an increase of 300%.

Machining costs have been cut by more than half. And because the center hole is "built-in", no steel is wasted.

The files of the Timken Company contain records of hundreds of problems that have been solved by Timken fine alloy steel. If you have a tough steel problem, why not bring it to us? Wire, write or phone The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

—ITEM 187—

For More Information Circle Item Number on Yellow Card—page 19

Guarantee **TOP** Performance and Maximum Life!

Specify THESE TOP QUALITY FEATURES...

(Standard on Miller Cylinders at no extra cost)

Specify CASE-HARDENED PISTON RODS

Benefits To You

CASE-HARDENED Piston Rods (52-54 Rockwell "C") provide practically complete protection against damage from hammer blows, wrench-dropping, mishandling, and similar occurrences. *Available from Miller at no extra cost.*

The HARD CHROME PLATING over the case-hardened rods protects against scratch-damage and rust. *Available from Miller at no extra cost.*

Specify TEFLON HYDRAULIC ROD SEALS

Benefits To You

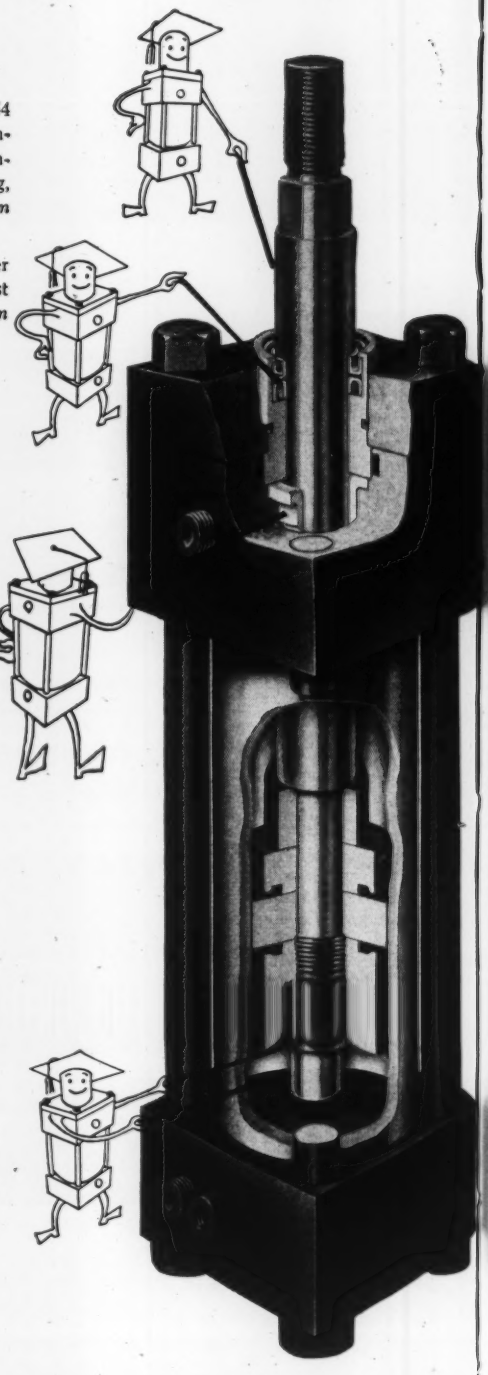
"TEFLON" Rod Wipers and "TEFLON" Hydraulic Piston Rod Seals withstand temperatures from—100°F. to plus 500°F. They are impervious to practically all known chemicals, including the fire-resistant, special, and standard hydraulic fluids in current use. *Available from Miller at no extra cost.*

Specify BLACK FERRIC OXIDE FINISH

Benefits To You

Highest quality Black Ferric Oxide Finish provides rust protection in air cylinder operation and on all cylinders during shipping and installation.

Cylinder heads, caps, mountings, pistons, followers, tie rods, and the unplated portions of the piston rods have this finish *at no extra cost on all Miller cylinders.* (This finish not recommended for water service)



You may wish to route this entire page to the proper department in your company, by using this handy form. Additional copies on request. →

To (Dept.)_____

"On all our future cylinder requirements, please specify the above quality features."

Signed_____

Title_____

See These New Features on Miller Cylinders at Miller

BOOTH No. 429

A. S. T. E. SHOW, March 19-23

International Amphitheatre, Chicago

SALES AND SERVICE FROM COAST TO COAST

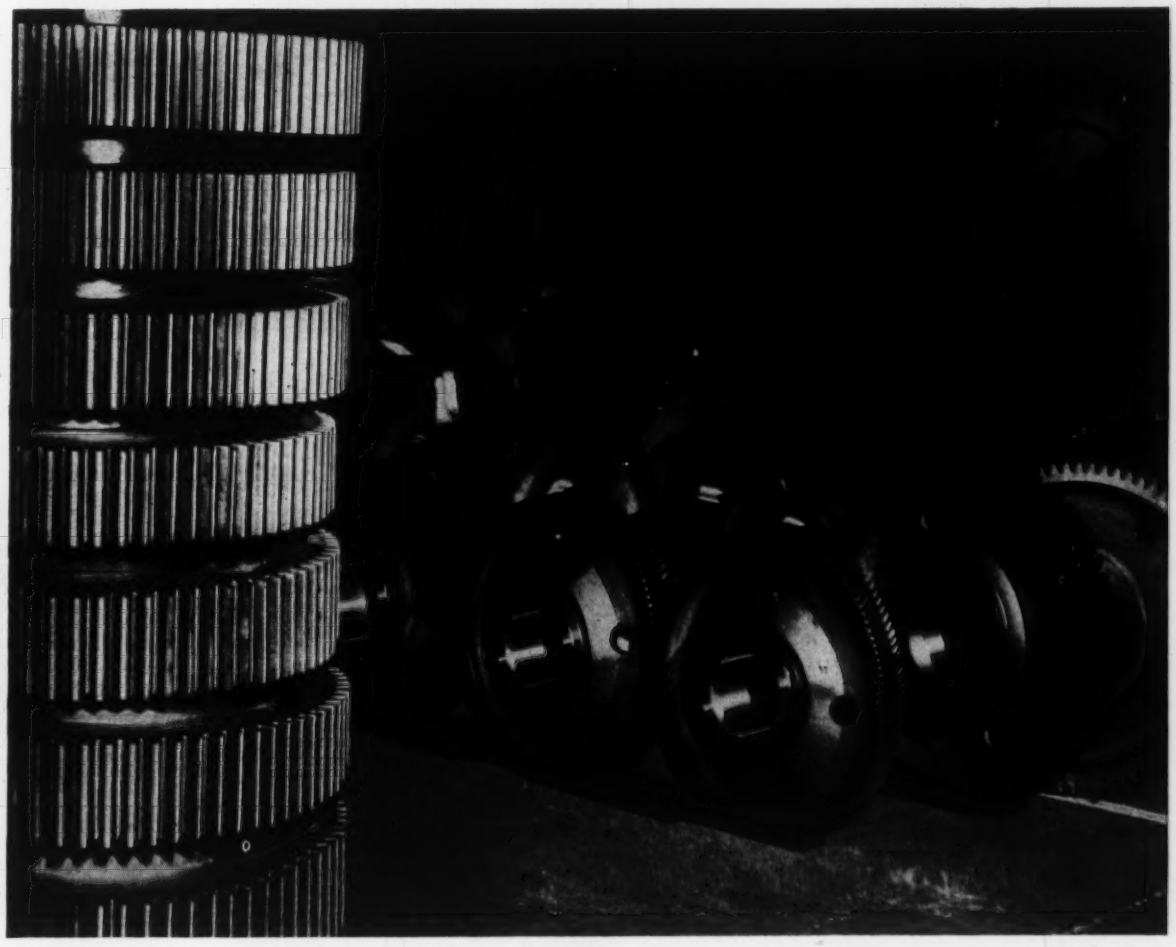
CLEVELAND • YOUNGSTOWN • DAYTON • TOLEDO • CINCINNATI • COLUMBUS
PITTSBURGH • PHILADELPHIA • BOSTON • HARTFORD • NEW YORK CITY
BUFFALO • ROCHESTER • MINNEAPOLIS • GRAND RAPIDS • DETROIT • FLINT
FORT WAYNE • SOUTH BEND • INDIANAPOLIS • MILWAUKEE • LOUISVILLE
KANSAS CITY • SEATTLE • LOS ANGELES • SAN FRANCISCO • BALTIMORE
DENVER • ST. LOUIS • MOLINE • CHICAGO • HOUSTON • ATLANTA
TORONTO, CANADA and OTHER AREAS

Miller

MILLER FLUID POWER CO.

2006 N. Hawthorne Ave., Melrose Park, Ill.

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS



The gear shop can be proud of these

To the shopman, few things are prettier than a well-machined gear — unless it's a whole inventory of well-machined gears. The stock above is a good example.

Here the beauty is more than skin-deep. The gears are as strong and tough as human skills can make them. All these gears were machined from Bethlehem blanks, which meant that they started with every advantage.

After all, the basis of any good gear is a good, sound blank. And you are certain of top-flight blanks when you get them from Bethlehem. For, at the Bethlehem shops, a special process has been developed for the making of gear blanks; a process that assures high strength, uniform grain flow, and excellent surface texture.

This method of manufacture is unique. It employs the only mill of its kind in the country . . . a mill that upsets, forges, and rolls the steel in a single operation. Let's stress that point. The blank is not just forged, not just rolled, but *both* . . . and both are important to the quality of the finished piece.

You're interested in quality, we know. So specify Bethlehem blanks for your spur, bevel, miter, helical, and other types of gears. You'll find these blanks equally good for crane wheels, industrial wheels, turbine rotors, clutch and brake drums, sheave wheels, flywheels, etc. They are available in sizes from 10 to 42 in. OD.

For additional information, ask us to send you Booklet 216. It is crammed with pictures and interesting data. No charge, of course; just drop us a card.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

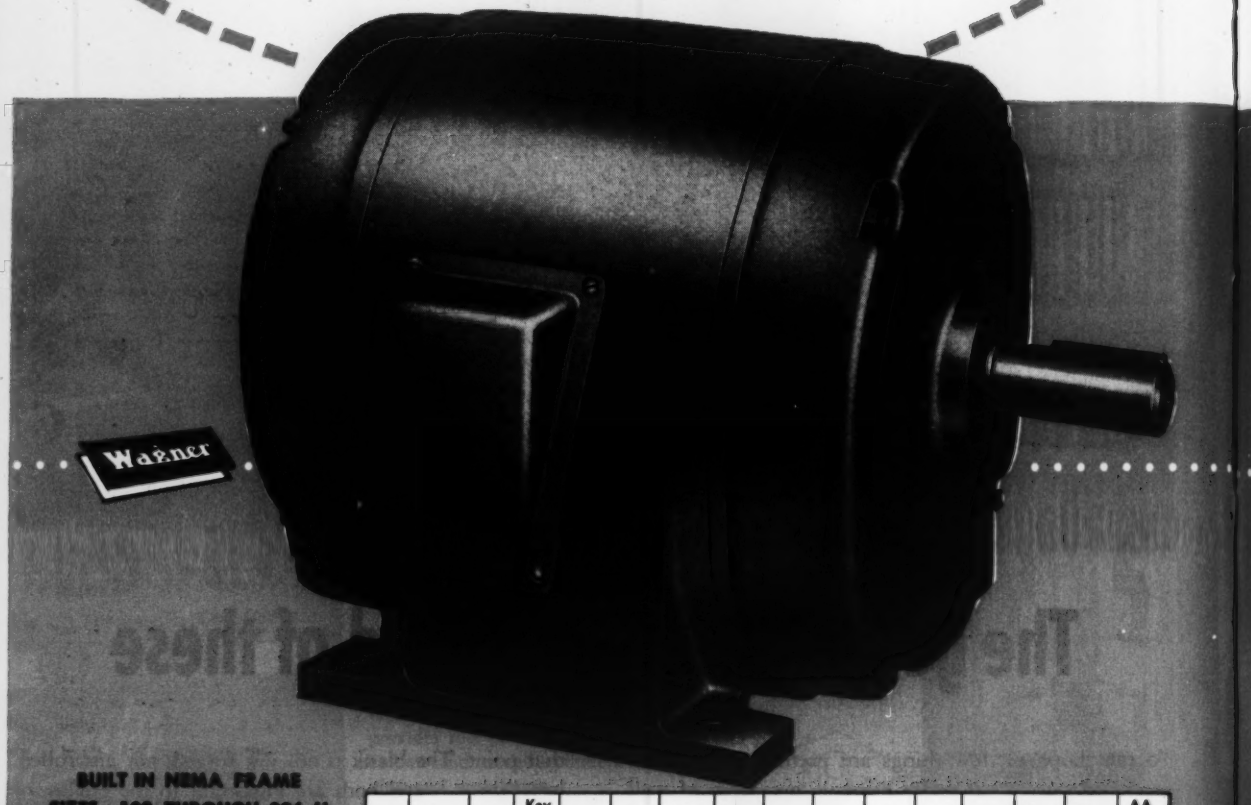
BETHLEHEM STEEL

Wagner

ELECTRIC MOTORS...the choice of leaders in industry

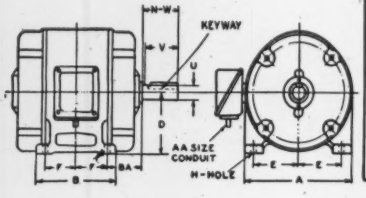
You get better performance with these New Wagner DP Motors

DOUBLY-PROTECTED



BUILT IN NEMA FRAME SIZES—182 THROUGH 326 U

FRAME SIZES AND DIMENSIONS
1 to 30 H. P.



HP	Frame No.	Key Width	Key Thickness	Key Length	A max.	B max.	D	E	F	BA	H	N-W	U	V min.	AA min. size of cond't
1	182	3/16	3/16	1 3/8	9	6 1/2	4 1/2	3 3/4	2 1/4	2 3/4	13/32	2 1/4	7/8	2	3/4
1 1/2	184	3/16	3/16	1 3/8	9	7 1/2	4 1/2	3 3/4	2 3/4	2 3/4	13/32	2 1/4	7/8	2	3/4
2	184	3/16	3/16	1 3/8	9	7 1/2	4 1/2	3 3/4	2 3/4	2 3/4	13/32	2 1/4	7/8	2	3/4
3	213	1/4	1/4	2	10 1/2	7 1/2	5 1/4	4 1/4	2 3/4	3 1/2	13/32	3	1 1/8	2 3/4	3/4
5	215	1/4	1/4	2	10 1/2	9	5 1/4	4 1/4	3 1/2	3 1/2	13/32	3	1 1/8	2 3/4	3/4
7 1/2	254U	5/16	5/16	2 3/4	12 1/2	10 3/4	6 1/4	5	4 1/8	4 1/4	17/32	3 3/4	1 3/8	3 1/2	1
10	256U	5/16	5/16	2 3/4	12 1/2	12 1/2	6 1/4	5	5	4 1/4	17/32	3 3/4	1 3/8	3 1/2	1
15	284U	3/8	3/8	3 3/4	14	12 1/2	7	5 1/2	4 3/4	4 3/4	17/32	4 1/8	1 5/8	4 3/8	1 1/4
20	286U	3/8	3/8	3 3/4	14	14	7	5 1/2	5 1/2	4 3/4	17/32	4 1/8	1 5/8	4 3/8	1 1/4
25	324U	1/2	1/2	4 1/4	16	14	8	6 1/4	5 1/4	5 1/4	21/32	5 3/8	1 7/8	5 3/8	1 1/2
30	326U	1/2	1/2	4 1/4	16	15 1/2	8	6 1/4	6	5 1/4	21/32	5 3/8	1 7/8	5 3/8	1 1/2

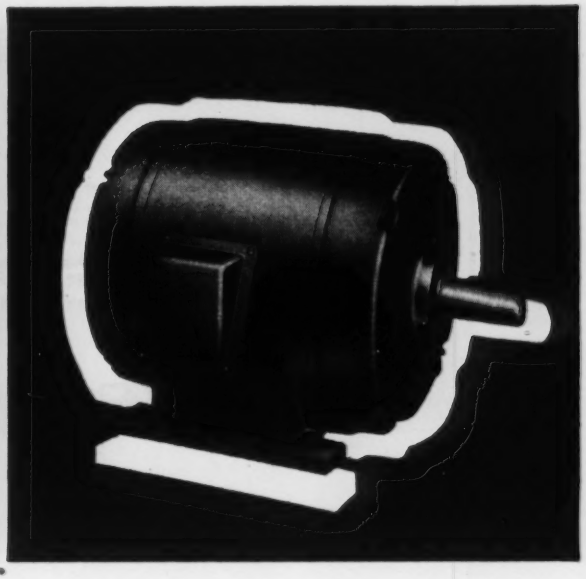
Wagner Electric Corporation
EST. 1891

WAGNER ELECTRIC CORPORATION
6404 Plymouth Ave. • St. Louis 14, Mo., U. S. A.

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS — AIR AND HYDRAULIC

BRANCHES IN 32 PRINCIPAL CITIES

M56-1

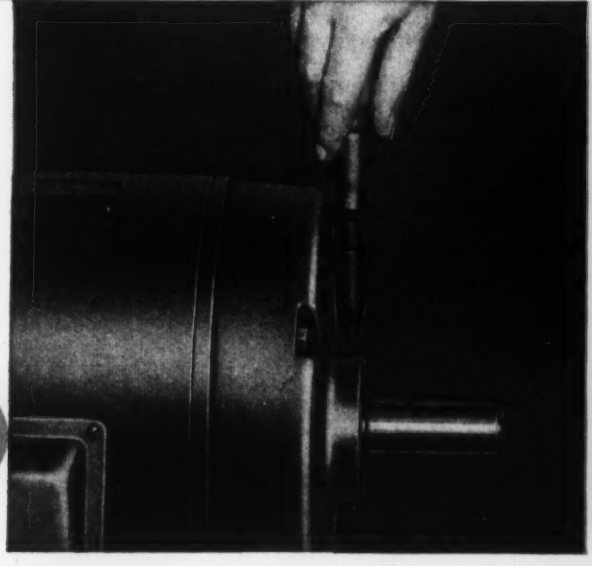


DOUBLY PROTECTED—Wagner DP Motors are protected by (1) rugged, corrosion-resistant cast iron frames, smoothly rounded so that no moisture can collect on them. Motor feet are cast as an integral part of the frame for maximum strength and rigidity. (2) Enclosures on the DP motor are completely drip-proof—virtually splashproof. Air intakes are located at the bottom of the endplates and air outlets are located at the base of the frame—one on each side.

MORE POWER IN SMALLER FRAMES—Wagner DP Motors are engineered to the new NEMA specifications which call for more power in smaller frames. The Wagner DP Motor packs more power in a smaller frame, but gives you the same quality and long life performance that have made Wagner Motors "the choice of leaders in industry" for many years. This smaller size means ease of handling and stocking . . . less space required for installation.

CAN BE RE-GREASED FOR LONGER LIFE—Wagner DP Motors will operate for years without re-greasing . . . the bearings are completely enclosed . . . however, provisions have been made for adding lubricant and for the removal of old grease in applications where re-greasing is necessary to prevent premature bearing failure—due, in most cases to inadequate lubrication rather than to inability to carry the load.

COOL RUNNING—Specially designed baffles direct cooling air from the blowers through the motor and provide protection for the stator windings. Blowers are cast as an integral part of the rotor squirrel-cage and are designed to move large volumes of air without vibration or objectionable noise. Cool running motors last longer.



now.....
VEEDER-ROOT
gives you

instant "push-button" resetting

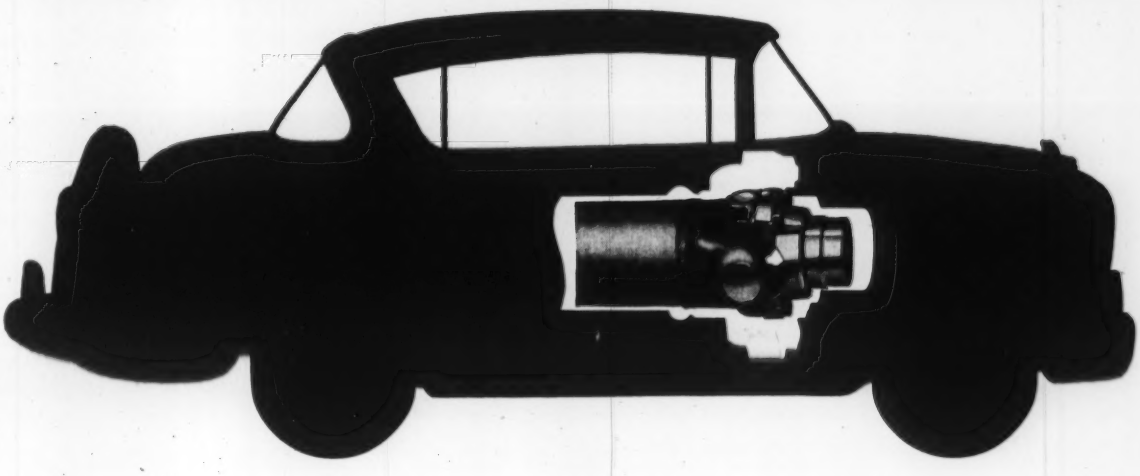
Just press the easy-acting lever on this Quick-Reset Ratchet Counter . . . *and all 4 figures reset to zero as instantly as though you used a push-button.* This saves time and speeds work on short machine runs, inspection and many other jobs. Counter is compact . . . 2.69″ long, 1.44″ high, 1.29″ wide. The 4 white-on-black figures are .166″ high. You can order it (Series 1126) from stock right now . . . just like scores of other Veeder-Root Counters for manual, mechanical and electrical operation in every field from electronics to atomics.

VEEDER-ROOT INCORPORATED
HARTFORD 2, CONNECTICUT
Greenville, S. C. • Chicago 6, Ill.
New York 19, N. Y. • Montreal 2, Canada
Offices and Agents in Principal Cities

EVERYONE CAN COUNT ON
VEEDER-ROOT
"THE NAME THAT COUNTS"

—ITEM 191—
For More Information Circle Item Number on Yellow Card—page 19

FIRST



FIRST to make an Automobile Joint smaller —(3-9/16″ swing diameter) to reduce the clearance needed by the low floor boards in modern cars.

FIRST to make the smaller joints stronger —(2500 lbs. ft. torque) to meet the needs of higher speed, higher power modern cars.

FIRST to make the smaller, stronger joints lighter—(20% less than other joints having the same torque capacity) to help designers keep overall weight down to modern standards.

FIRST to make the smaller, stronger, lighter joints easier to install—(less parts to handle) to save time and money on the assembly line.

Send a print and specifications of your new model for MECHANICS engineers' recommendations how you can give your next car the benefit of these four competitive advantages—provided by the new MECHANICS joint development.

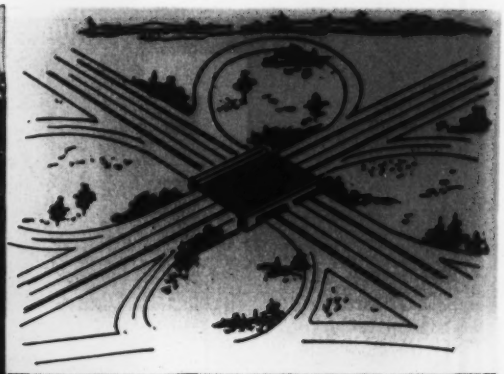
MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2032 Harrison Ave., Rockford, Ill.
Export Sales: Borg-Warner International
79 E. Adams, Chicago 3, Illinois

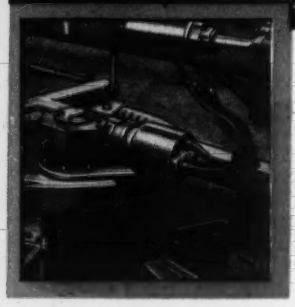
MECHANICS

Roller Bearing B-W

UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment





GALION 104 Motor Grader, above, uses Eastman Assemblies on *EIGHT* Hydraulic controls for more accurate, effortless and economical grading. Close-up, left, shows powerful Hydraulic Circle Turn for famous Galion "Reversible" Moldboard.

BARBER-GREENE Bituminous Finisher, right, automatically lays level finish for smoother, safer travel. Close-up shows Eastman Hydraulic Hose Assembly delivering 2,700 lbs. pressure to raise and lower finishing screed.

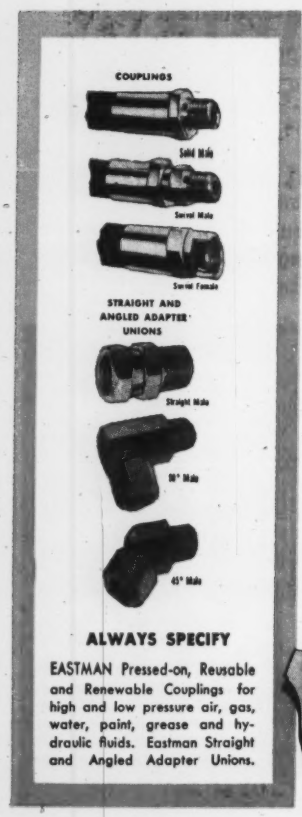
Smoother, Safer Roads

BUILT WITH HYDRAULIC POWER

DELIVERED THROUGH

Eastman

HYDRAULIC HOSE ASSEMBLIES



ALWAYS SPECIFY

EASTMAN Pressed-on, Reusable and Renewable Couplings for high and low pressure air, gas, water, paint, grease and hydraulic fluids. Eastman Straight and Angled Adapter Unions.

Smoother, safer highways are being built today through the application of modern engineering and the use of modern equipment—much of which is hydraulically operated—using Eastman Hydraulic Hose Assemblies.

GALION—pioneer builder of road machinery—whose Motor Graders and Rollers are used 'round the world—first used hydraulic controls as early as 1927. Eastman Mfg. Co. pioneered in the development of Hydraulic Hose Assemblies in 1926—and *Galion is Eastman equipped today!*

BARBER-GREENE—whose Bituminous Road Finishers have been used at one time or another on almost every road ever built—also uses Eastman Hydraulic Hose Assemblies. Hydraulic power is used to raise and lower the all-important mechanism which lays a level finish—regardless of irregularities in the base. Barber-Greene's founding date of 1916 closely parallels Eastman's of 1914—and *Barber-Greene is Eastman equipped today!*

EASTMAN—*first in the field*—is proud to have pioneers such as Galion and Barber-Greene—as well as many other leading American manufacturers—use Eastman Hydraulic Hose Assemblies. Look to Eastman for *continued leadership* in engineering and design for quality of material and workmanship—plus better-than-ever service through expanded production facilities of our new, modern plant.

SAFEGUARDING INDUSTRY'S Lifeblood of Mobile Power

Eastman

first in the field

MANUFACTURING COMPANY

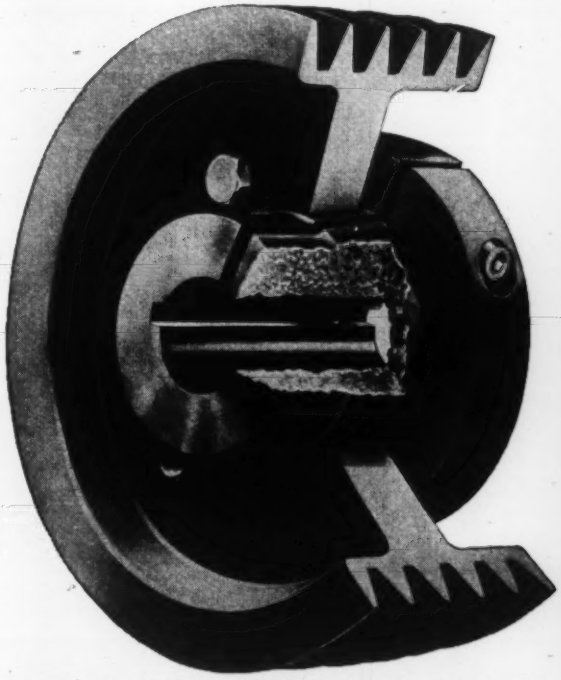
Dept. MD3, Manitowoc, Wis.

WRITE for Eastman Catalog or send blueprints stating your hydraulic requirements and specifications.

—ITEM 193—

For More Information Circle Item Number on Yellow Card—page 19

Why specify one sheave instead of another?

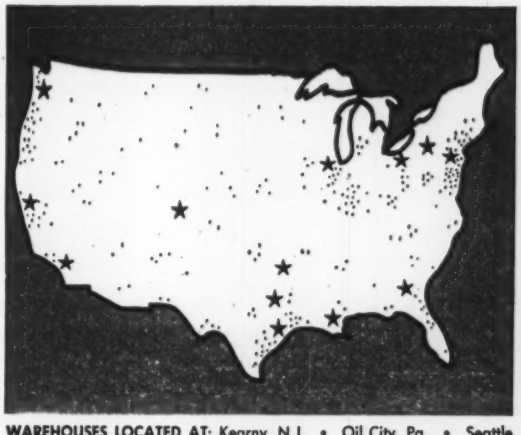


TAKE A CLOSE LOOK at this cutaway view of the Worthington QD — the *original* two-piece sheave. See how unique two-piece construction makes it easy to get on, easy to get off. But its heavy-duty split-tapered-cone hub grips shaft tightly, holds fast under the heaviest shock loads.

Some folks seem to think there's no difference between sheaves. No matter who makes them or sells them, a sheave's a sheave and a V-belt's a V-belt. Period.

Not our users, though. They know *our* sheave (the Worthington QD) *is* different. More to the point, they know it's *better* than other sheaves. And easier to get, too. There are Worthington service outlets practically everywhere. Never any delays in stock shipment or service! MV.5.4

SCIENTIFIC DESIGN of QD sheaves not only provides more efficient transmission of power but actually adds to the looks of your product. What's more, I-beam construction of the QD driveN sheaves provides greater strength with less weight.



WAREHOUSES LOCATED AT: Kearny, N.J. • Oil City, Pa. • Seattle San Francisco • Los Angeles • Denver • Tulsa • Ft. Worth • Houston New Orleans • Chicago • Cleveland • Atlanta, Ga.

PROMPT SHIPPING SERVICE. Thirteen factory warehouses with stocks covering over 100,000 V-belt drive stock combinations, from ½ to 600 horsepower, support over 250 stocking distributor outlets. These shipping centers can fill your requirements *fast*.

GOOD NEWS for engineers: This free, 100-page "Master Engineering Manual" makes sheave and V-belt selection as easy as falling off a drive shaft. Write for it today to Worthington Corporation, Mechanical Power Transmission Division, Section MV.5.4, Oil City, Pa.

WORTHINGTON

SPECIFY THESE WORTHINGTON STANDARD PRODUCTS ON YOUR EQUIPMENT

Compressors • Pumps • Multi-V-Drives • Variable Speed Drives

—ITEM 194—

For More Information Circle Item Number on Yellow Card—page 19

Aluminum part cuts costs

Screw Machine Data—Aluminum Windshield Wiper Knob Insert—Ford Motor Company

MACHINE: 5 Spindle Davenport Automatic

OPERATING DATA:

Turning—3000 R.P.M.—295 S.F.P.M.

Knurling—Diamond knurl—3000 R.P.M.—295 S.F.P.M.

OPERATIONS: Feed, Center, Drill, Knurl, Form, Cut-off

CYCLE TIME: 2.4 seconds

PARTS PER HOUR: 1500

EFFICIENCY: 80%

STOCK: ⅜" round, aluminum 2011-T3

for Ford Motor Company

THE Ford Motor Company recently changed its specifications on the Ford car windshield wiper knob insert to aluminum. This Ford part is one of several new screw machine parts now made from aluminum. They are currently studying other screw machine parts for possible conversion to aluminum.

This conversion met the requirements of management, design engineering and production groups.

MANAGEMENT REQUIREMENT: Savings

Change to aluminum saved approximately 24.8%. Ford management is always interested in materials or methods that will effect savings with no sacrifice in quality. In this particular case, as in others, aluminum seemed to be the logical material because it provided savings of about 24.8% per piece, including scrap loss. Also, the aluminum parts are so much lighter than the previously used metal, that Ford has realized additional savings in shipping costs.

DESIGNER REQUIREMENT: Performance

Aluminum met design specifications. Ford engineers selected aluminum alloy 2011-T3, ⅜" round stock after they tested other metals and found that the aluminum knob insert would not only provide sufficient strength but would also take a slightly better knurl. The fact that aluminum satisfied performance requirements and for less money than other metals tested, was the main consideration in Ford's selection of aluminum.

OPERATOR REQUIREMENT: Machinability

Aluminum machined at maximum efficient cutting speed. The changeover to aluminum for this knob insert did not require any change in machining speed and setting from the previous metal used. Ford is running the part successfully at the maximum efficient speed of the automatic screw machine. And Ford found that it was not even necessary to change the angle of the form tool, which is an ordinary high speed steel tool with no chip-breaker.

The experience and engineering know-how of Ford has proved that properly designed aluminum parts can often provide substantial economies plus high quality.

Aluminum Screw Machine Stock Offers These Big Advantages

You get three times as many parts from a pound of Kaiser Aluminum stock as from a pound of brass or steel. And you often get *better* parts because aluminum provides a unique combination of advantages, including lightness with strength, handsome finish, corrosion resistance, good heat and electrical conductivity.

For more information or assistance, look for our local number in the classified telephone directory under the heading "Aluminum."

Kaiser Aluminum & Chemical Sales, Inc. *General Sales Office*, Palmolive Building, Chicago 11, Illinois; *Executive Office*, Kaiser Building, Oakland 12, California.

Kaiser Aluminum

setting the pace—in growth, quality and service

HELIARC Cutting

TRADE-MARK

CUTS ALUMINUM AT SPEEDS UP TO 300 INCHES PER MINUTE

HELIARC cutting, a new process developed by LINDE, brings all the desired features of economical high-speed operations to the cutting of aluminum.

★ **Speeds never before possible:** Normal mechanized cutting speeds are 300 in. per min. in ¼-in. material, 125 in. per min. in ½-in. material, 75 in. per min. in ¾-in. material, and 50 in. per min. in 1-in. plate. If desired, lower speeds can be obtained by simply adjusting the controls.

★ **Straight lines, bevels, contours—no problem:** The new HELIARC cutting process can be used mechanically or manually. Both setups produce high-quality straight line cuts, bevels, circles, and shapes with revolutionary new speed and efficiency.

HELIARC cutting employs a high-temperature, high-velocity, constricted arc between a tungsten electrode and the piece to be cut. The concentrated, columnated energy of the arc stream melts and ejects a thin section of metal to form a kerf. The gas atmosphere (a combination of argon and hydrogen) prevents oxidation of the cut face.

Learn the details of how HELIARC cutting can help you increase production and cut operating costs. Call your LINDE Representative today.

Linde Air Products Company

A Division of Union Carbide and Carbon Corporation

30 East 42nd Street UCC New York 17, N. Y.

Offices in Other Principal Cities

In Canada: LINDE AIR PRODUCTS COMPANY

Division of Union Carbide Canada Limited, Toronto

Linde Trade-Mark

"Heliarc" and "Linde" are registered trade-marks of Union Carbide and Carbon Corporation.

—ITEM 196—

For More Information Circle Item Number on Yellow Card—page 19

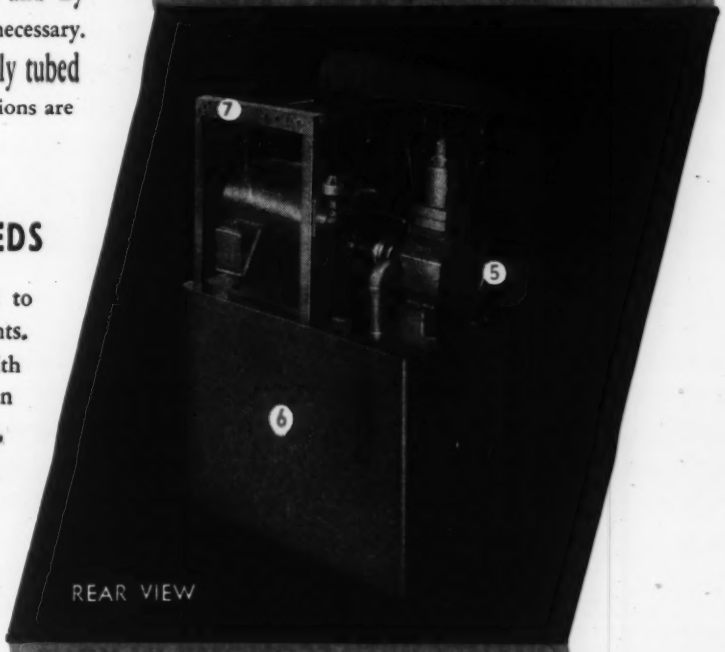
RACINE

HYDRAULIC POWER PLANTS

A RACINE packaged Power Unit offers you maximum flexibility in operation and performance. It comes complete, ready for immediate installation on your equipment.

The heart of this system, a RACINE Variable Volume Pump, conserves horsepower by putting all of the oil to work. Relief and By-pass Valves with extra piping are unnecessary. On this unit all control valves are neatly tubed to a terminal block from which connections are made to the machine.

FRONT VIEW



REAR VIEW

DESIGNED FOR YOUR NEEDS

These package units can be designed to meet your space and circuit requirements. All components are centrally located with the Control Valves positioned on an easily accessible control panel. Investigate the possibilities as applied to your products. Write for complete RACINE Hydraulic Catalog and the name of your nearest RACINE Field Office offering a complete engineering service.

KEY TO PARTS

1. RACINE FEED VALVE
2. RACINE DIRECT SOLENOID OPERATED 2-WAY VALVE
3. RACINE DIRECT SOLENOID OPERATED 4-WAY VALVE
4. GLOBE SHUT-OFF VALVE
5. RACINE VARIABLE VOLUME PUMP
6. RACINE OIL RESERVOIR
7. TERMINAL BLOCK

SALES AND SERVICE REPRESENTATIVES IN ALL PRINCIPAL CITIES

"They Work Better Together"

RACINE HYDRAULICS & MACHINERY, INC.
2573 Albert Street, Racine, Wisconsin, U.S.A.

—ITEM 197—

CURTISS-WRIGHT METALS PROCESSING DIVISION CAN COMBINE QUALITY WITH ECONOMY IN YOUR PRODUCTION TOO!

This nickel alloy casting by the Curtiss-Wright Metals Processing Division costs 40% less than identical previous castings. The saving, however, is almost a sidelight to the fact that specialized know-how can discover routes to quality that are often far shorter as well as less expensive.

High Standards, Lower Cost

In this case the answer to meeting high standards and lower cost was ceramic mold instead of investment casting. This method in experienced hands retained the close tolerances required . . . produced castings faster, and with gratifying economy.

Metals Processing Division metallurgical specialists can find answers for you, whether in ceramic, shell, centrifugal or other techniques . . . standard or special. You will profit by long-proven engineering ability and unmatched facilities in production and testing. When requirements are critical, when precision must be combined with resistance to heat, stress, wear and corrosion, it's time to call on Curtiss-Wright—a primary source for castings, forgings and extrusions.

METALS PROCESSING DIVISION
CURTISS-WRIGHT CW
CORPORATION • BUFFALO, NEW YORK

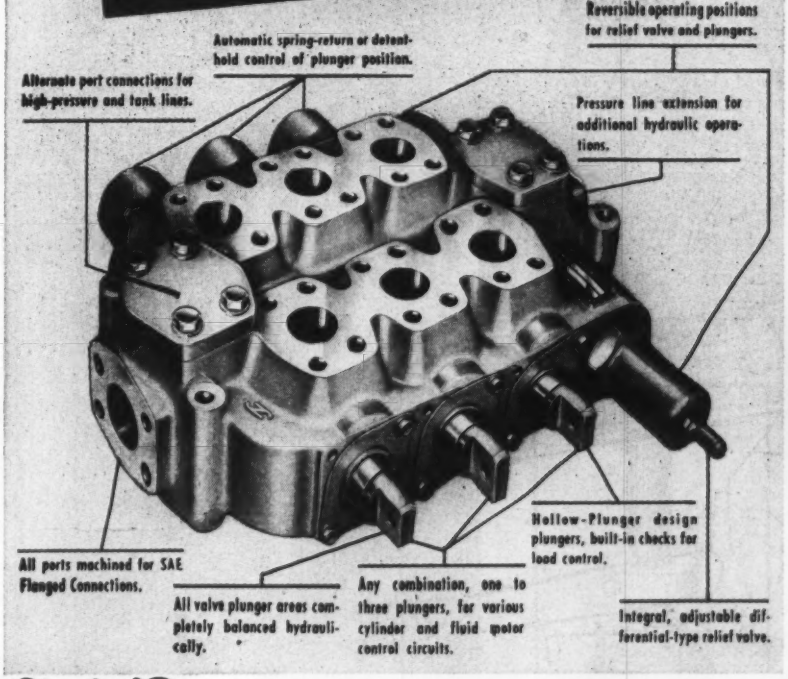
71 Grider Street, Buffalo, New York

—ITEM 198—
For More Information Circle Item Number on Yellow Card—page 19

BIG VALVES FOR BIG JOBS

A New Series HYDRECO® HOLLOW-PLUNGER CONTROL VALVES

25-50-100 gpm to 2000 psi


Reversible operating positions for relief valve and plungers.
Automatic spring-return or detent-hold control of plunger position.
Alternate port connections for high-pressure and tank lines.
Pressure line extension for additional hydraulic operations.
Hollow-Plunger design plungers, built-in checks for load control.
All ports machined for SAE Flanged Connections.
All valve plunger areas completely balanced hydraulically.
Any combination, one to three plungers, for various cylinder and fluid motor control circuits.
Integral, adjustable differential-type relief valve.

Oil Power for BIG MACHINES

Built-in Checks to prevent load drop while shifting plungers . . . *Improved Throttling* for accurate control . . . *Complete Hydraulic Balance* of all plunger areas . . . this is the BIG NEWS in these new HYDRECO Valves for builders of BIG Machines. HYDRECO *Hollow-Plunger* Valves give hair-line control at *all* times, and, of vital importance with large machines handling heavy loads, there is no load drop when operating positions are changed — no sag, even when power is cut off!

These new HYDRECO Valves make single-acting or double-acting control readily available and provide control for Fluid Motors or for four-position float operation. Relief Valve adjustment and levers can be installed on either side of the Valve.

Member NFPA

Write for complete information on the new HYDRECO Control Valves and companion Hydraulic Pumps for your BIG JOBS.

KALAMAZOO DIVISION
THE NEW YORK AIR BRAKE COMPANY

9006 E. MICHIGAN • KALAMAZOO • MICH.

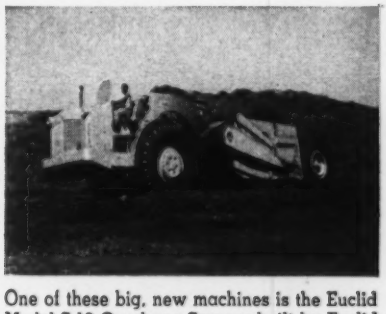
INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N. Y.

Fluid Power Speeds Turnpike Construction

CEILING ON CONSTRUCTION EQUIPMENT SIZES LIFTED

Modern turnpike construction calls for moving mountains or filling valleys . . . fast, and at lowest cost. To solve this problem, designers of construction equipment are creating machines that are bigger, faster and easier to handle than was believed possible only a few years ago. With every increase in size, weight and load the problems of operation and control multiply and exceed the ability of conventional hydraulic components to handle the job.

Engineers of The New York Air Brake Company faced this challenge and provided the answer . . . a completely new line of high capacity Gear Pumps and Valves. Today, design engineers can confidently employ circuits requiring up to 100 gpm and 1500 psi; thus lifting the ceiling on size, speed and capacity AND at realistic cost!



One of these big, new machines is the Euclid Model S-18 Overhung Scraper built by Euclid Division, General Motors Corporation, shown here. On this unit, Euclid engineers have specified big HYDRECO Pumps for fluid power and Series V28 HYDRECO Valves for control of scraper operations. A small HYDRECO Pump powers the hydraulic steering circuit. As big as these machines are, HYDRECO Oil Power gives them real "finger-tip" control.

The New York Air Brake Company also offers many other advanced type hydraulic components for designers of heavy-duty mobile equipment . . . DUDCO Dual-Vane Pumps to 150 gpm and 2000 psi; DUDCO and HYDRECO Fluid Motors; HYDRECO Control Valves and Hydraulic Cylinders.

ENGINEERS

Exceptional opportunities for men of imagination to express new ideas in the design and development of Hydraulic Components. Company expansion and progress in this growing industry promise rewarding futures for engineers who qualify. Write, giving experience and full details.

KALAMAZOO Division
The New York Air Brake Company
9006-3 E. Michigan
Kalamazoo, Michigan

Gentlemen:

I would like more information on the new HYDRECO Control Valves for BIG Mobile Equipment. ☐ Also details on HYDRECO 3600 Series Pumps. ☐

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

—ITEM 199—

PHOENIX Custom Rubber Molding

we will work with you!

Our knowledge and experience gained from twenty years' development work is at your disposal. Should you desire assistance in mold, die, or product design, you have only to call on us.

We have this to offer:

SKILLED CRAFTSMANSHIP
STRICT QUALITY CONTROL
AN UNUSUAL ABILITY TO MAINTAIN
THE CLOSEST OF TOLERANCES

Our reputation for maintaining customers' confidences to the letter is well known.

address all inquiries to

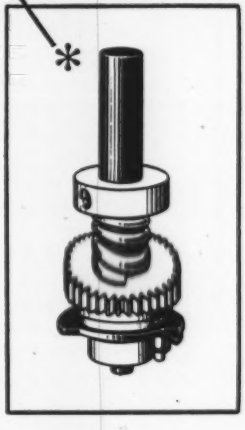
RUBBER PRODUCTS DIVISION
PHOENIX MANUFACTURING COMPANY
Joliet, Illinois

—ITEM 200—
For More Information Circle Item Number on Yellow Card—page 19

Design Simplicity — Key to Trouble-Free Operation

1. Easy setting on full-view scale.
2. Quality switches rigidly mounted.
3. Housing encloses, protects mechanism.
4. Powerful Cramer synchronous motor.
5. Bakelite base ruggedly constructed.

CRAMER
type 230
INTERVAL
TIMER
. . . manually set to control the opening of one circuit and closing of another for a selected time interval.



A "look inside" the Type 230 Interval

Timer illustrates how design simplicity and precision workmanship contribute to trouble-free performance.

For example, the friction clutch assembly shown at left has few operating parts, yet is highly efficient. All friction forces are held internally within the clutch. No force is exerted either up or down to cause unnecessary load on the motor. The clutch essentially "floats" in the timer, thus minimizing wear, increasing reliability, and contributing to long motor and timer life.

Every component of every Cramer timer has been designed for simplicity, accuracy and operating dependability. For the complete story on interval timers, write for Bulletin PB-210.

Cramer TIMING DEVICES

SPECIALISTS IN TIME CONTROL

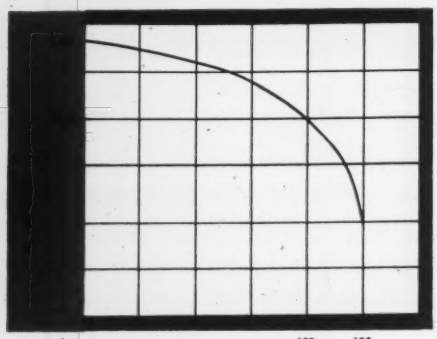
The R. W. CRAMER CO., Inc.

BOX 6, CENTERBROOK, CONNECTICUT

7CR55

—ITEM 201—

Factors Determining the Choice of HOWARD FRACTIONAL H.P. *INDUCTION MOTORS*



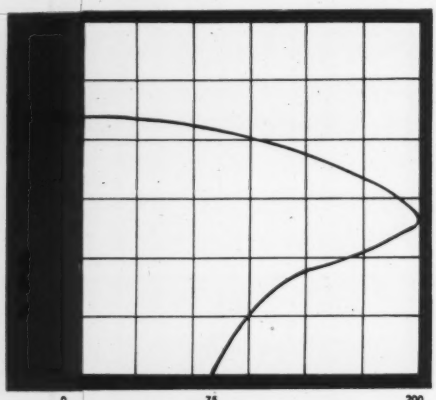
% TORQUE TORQUE TYPE MOTOR

TORQUE TYPE MOTOR

POWER: AC 50 to 60 cycles.

CHARACTERISTICS:

1. No Load speed is determined by number of poles, with a No Load slip of approximately 5%.
2. Full Load speed decreases with an increasing load. Designed to operate at approximately 30% full load slip.
3. No breakdown torque.
4. Starting torque high approximately 125% full load.



% TORQUE INDUCTION CAPACITOR RUN TYPE MOTOR

INDUCTION CAPACITOR RUN TYPE MOTOR

POWER: AC 50 to 60 cycles.

CHARACTERISTICS:

1. No Load speed is determined by the number of poles, with a no load slip of 2 to 4%.
2. Constant Full Load speed, with a full load slip of approximately 10%.
3. Breakdown torque—approximately 200% full load.
4. Starting torque—approximately 75% full load.

HYSTERESIS SYNCHRONOUS TYPE MOTOR

POWER: AC 50 to 60 cycles.

CHARACTERISTICS:

1. Synchronized speed, determined by number of poles.
2. Starting torque equal to Full Load Torque.
3. Quiet operation.

RELUCTANCE SYNCHRONOUS TYPE MOTOR

POWER: AC 50 to 60 cycles.

CHARACTERISTICS:

1. Synchronized speed, determined by the number of poles.
2. Starting Torque Low, 50 to 75% of Full Load.

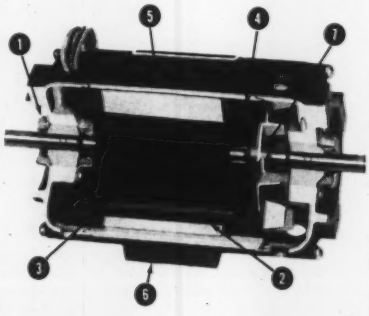
The increase in the use of Howard Induction Motors results from the overall superior performance characteristics of Induction motors over Series and Shaded Pole types.

basically Howard Induction motors have the following advantages!

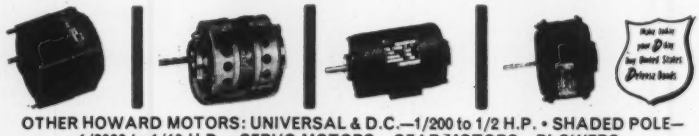
- Less maintenance—no brushes to wear, parts subjected to less wear. For applications where maintenance is difficult to handle.
- Constant speed under increasing load or varying power supply—for applications with exacting timing requirements where load or power supply are not constant.
- Extremely quiet operation both mechanically and electrically—for applications where noise level must be exceptionally low, professional tape recorders, etc.
- Low external field, in many cases requiring no magnetic shielding.
- Good efficiency up to 50% as against 40% maximum in Shaded Pole motors and 65% in Series motors.
- High power factor up to 85%.
- No radio or TV interference—for appliances and other home use applications.
- Good starting torque.
- Reversible in motion and reversible from rest.
- Wide range of H.P. ratings (1/8 to 1/1400) and gear ratios (2:1 to 3600:1).

Howard Induction Motors are currently used in a wide range of applications—business calculators, tape recorders, facsimile equipment, blowers for microwave relay stations, radar, projectors, teleprinters, gyro drives, automation instruments, etc.

Howard Induction Motors are available in Torque, Induction Capacitor Run, Hysteresis Synchronous and Reluctance Synchronous types. Costs are moderate but depend upon quantity. For full information on Howard Induction Motors, write for bulletin 56A.



1. "Selected" ball bearings permanently lubricated, sealed and shielded or sleeve bearings with large felt oil reservoirs with oil return system (shown). Sleeve bearing motors can be provided with ball thrust bearing for vertical operation or thrust loading.
2. 24 slot lamination design for quiet, cool operation. Stamped from high grade electrical steel.
3. Rotors dynamically balanced, skewed to give uniform torque characteristics with change of rotor angle.
4. Windings of heavy Formex insulated wire, impregnated and baked with top grade electrical varnish.
5. Case of sturdy, rigid casting always.
6. Mounting pads with holes drilled and tapped cast on frame. Special face mounting end bell available.
7. Internal fan for cooling.



OTHER HOWARD MOTORS: UNIVERSAL & D.C.—1/200 to 1/2 H.P. • SHADED POLE—1/2000 to 1/10 H.P. • SERVO MOTORS • GEAR MOTORS • BLOWERS

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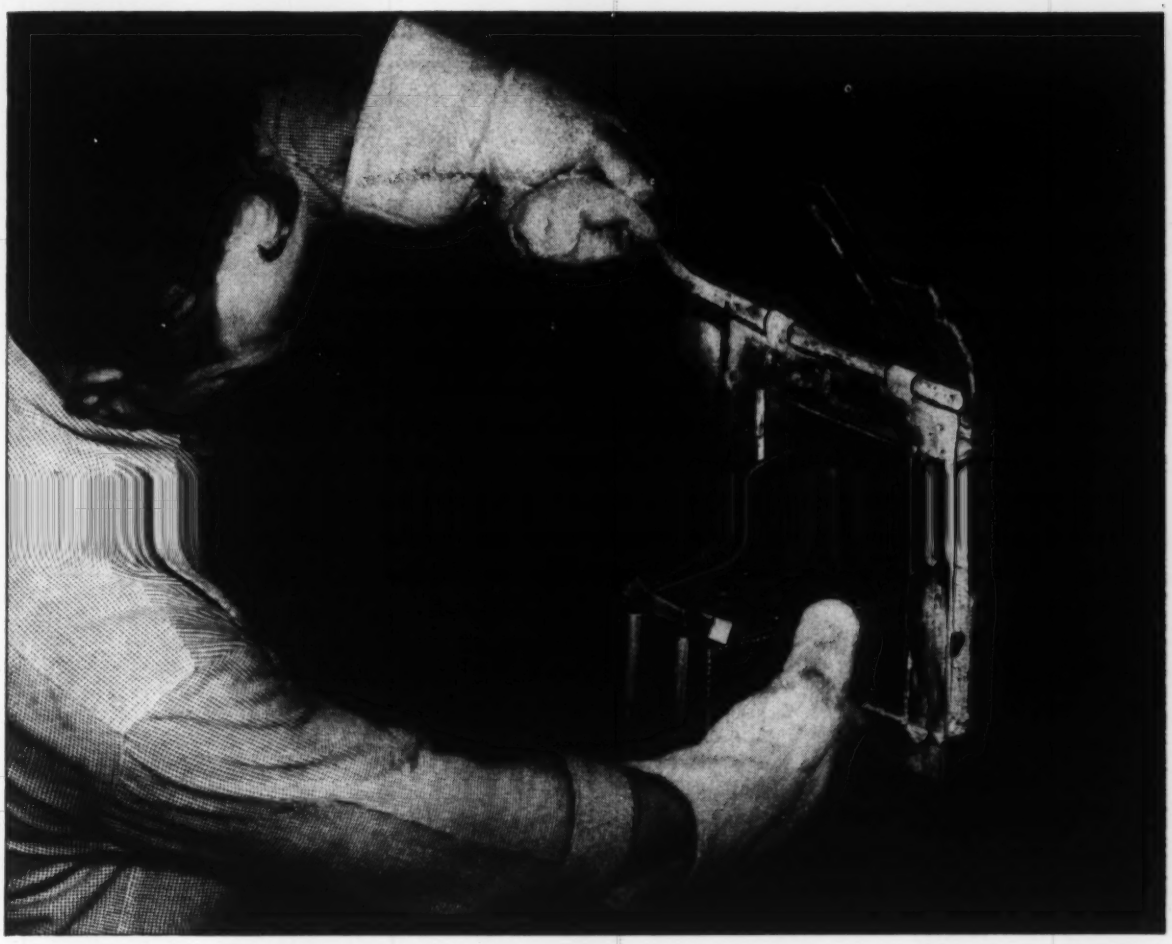
DIVISIONS: EMC ELECTRIC MOTOR CORPORATION · CYCLOHM MOTOR CORPORATION · REP RACINE ELECTRIC PRODUCTS

ITEM 202



720 Hours at 2300 Deg. F ...Didn't Hurt This Muffle

Continuous exposure at 2300 deg. F had little effect on a muffle made of HASTELLOY alloy X and used in this electric annealing furnace. The muffle was subjected to the intense heat for an entire month, 24 hours a day. After this extended service it was examined, found to be in excellent condition, and put back in service.

Actually, HASTELLOY alloy X solved a dual problem for this Company. The muffle is used in a furnace for annealing cold-drawn parts. Periodically, it is used for annealing superalloy parts at 2300 deg. F. Most of the time, however, it is used to anneal stainless steel parts at lower temperatures. Other materials were either inadequate for this service or too costly. Only HASTELLOY alloy X could handle both conditions economically.

HASTELLOY alloy X is a wrought high-temperature alloy with excellent strength and oxidation resistance to 2300 deg. F. For a copy of a booklet describing HASTELLOY alloy X, get in touch with the nearest sales office listed below.

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A Division of Union Carbide and Carbon Corporation

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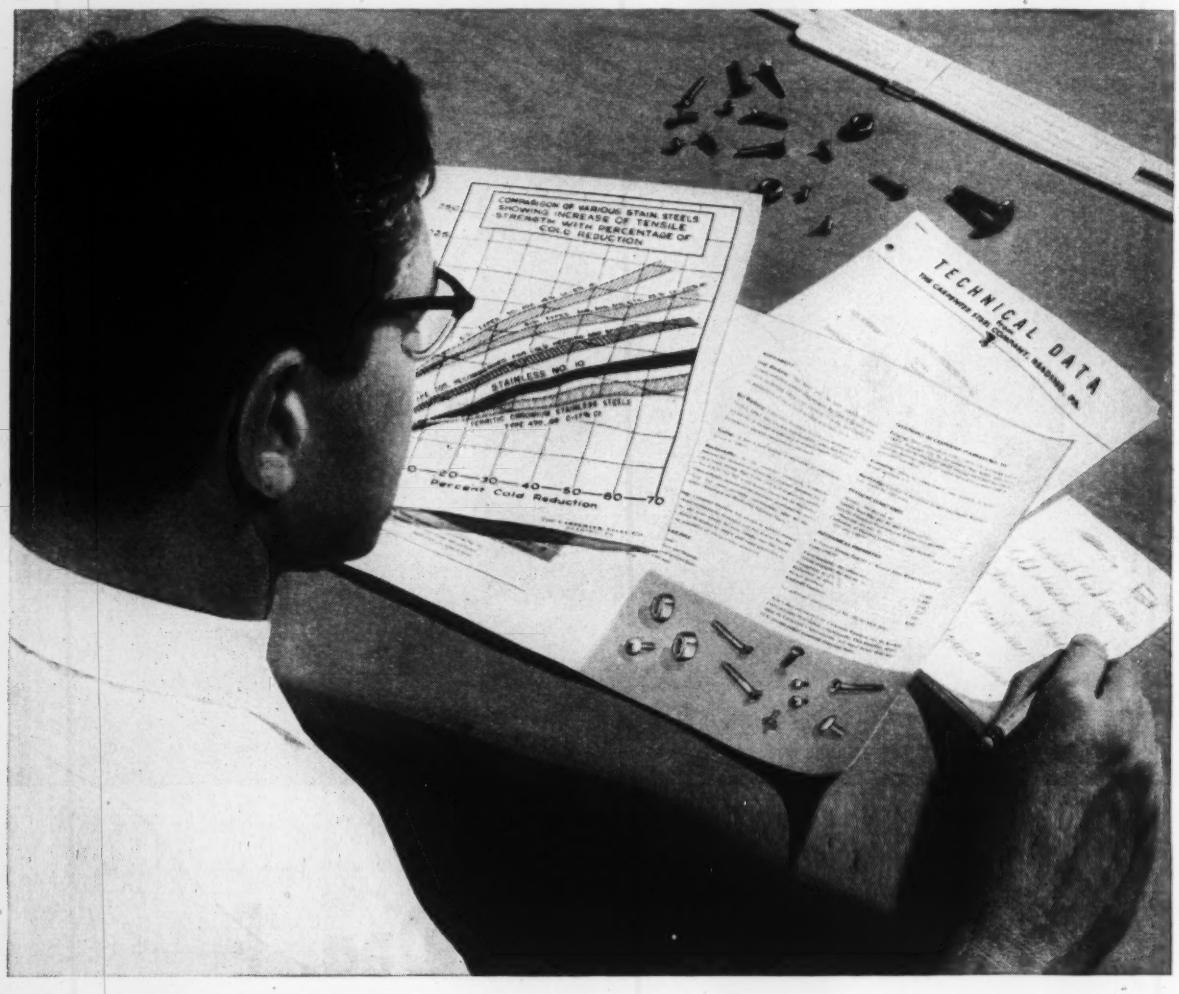
—ITEM 203—

Carpenter... pioneering in improved Tool, Alloy and Stainless Steels through continuing research


COMPARISON OF VARIOUS STAIN STEELS SHOWING INCREASE OF TENSILE STRENGTH WITH PERCENTAGE OF COLD REDUCTION
STAINLESS NO. 10
Percent Cold Reduction
TECHNICAL DATA

How Can You Improve Your Parts With This New, EASIER TO COLD WORK Stainless?

A new combination of properties in Carpenter Stainless No. 10 gives you greater flexibility in designing and fabricating cold formed parts than you get with any other type of chrome-nickel stainless.

Many chrome-nickel stainless parts which you previously considered too difficult or costly to cold head or upset on a mass production basis, can now be economically mass produced from No. 10 without process annealing. Its slower work hardening also makes No. 10 a "natural" for difficult coining, extrusion and swaging operations.

Also Carpenter Stainless No. 10 remains non-magnetic after severe cold working—an important advantage for instrument parts which must be non-magnetic after fabrication. And No. 10 possesses corrosion resistance equal to or better than standard chrome-nickel stainless steels.

If you have had difficulty in producing or obtaining such parts, perhaps this radically different chrome-nickel stainless will enable you to switch to cold forming . . . adding inherent benefits to your product.

Get the full story on No. 10. Talk it over with your Carpenter representative or write on your company letterhead to *The Carpenter Steel Company, 120 W. Bern St., Reading, Pa.*

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CHICAGO ..... MARCH 19-23, 1956

Carpenter STEEL

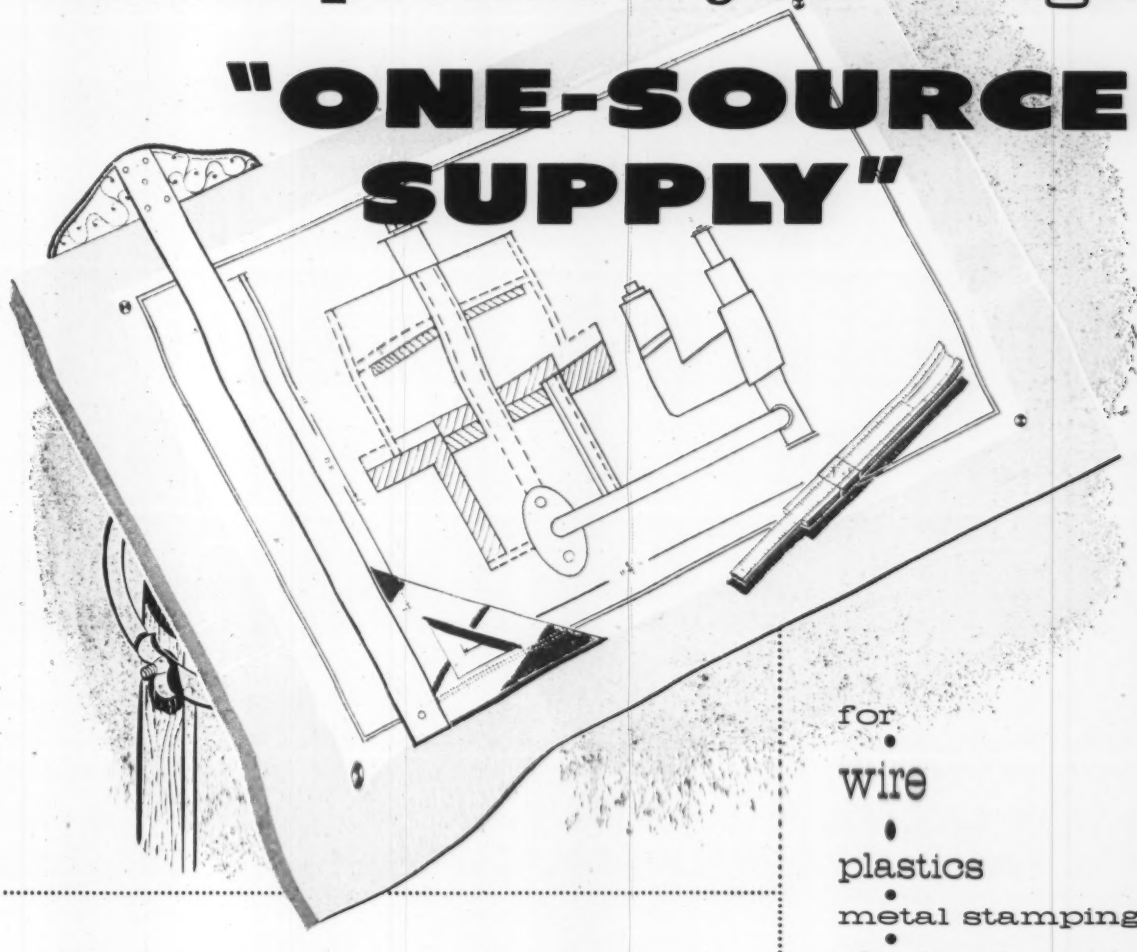
stainless no. 10

Export Department: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

—ITEM 204—
For More Information Circle Item Number on Yellow Card—page 19

for the products you design

"ONE-SOURCE SUPPLY"



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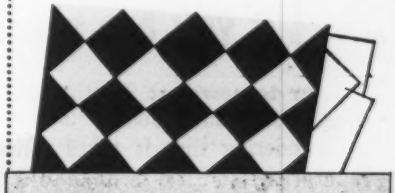
- wire
- plastics
- metal stampings
- electronic parts

Designers find Sylvania Parts Division unusually helpful in producing parts for the products they design.

The reason? Sylvania offers unique four-way service, made possible by complete facilities for cold-drawn wire, custom-molded plastics, metal stampings, and electronic parts.

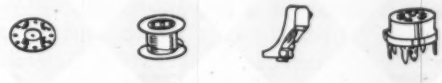
At Sylvania the emphasis is on "custom tailoring" these facilities to meet your particular needs.

For more information on Sylvania's "one-source supply," write for the new "Portfolio of 4-way service to designers." Address Dept. C52S.



Sylvania invites you
to call on the
Parts Division for
consultation at any time
without obligation

PARTS DIVISION



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Welds readily . . . excellent for soldering and brazing

—ITEM 206—

For More Information Circle Item Number on Yellow Card—page 19

MACHINE DESIGN
MARCH 8, 1956

A Commodity or A Profession?

THE TROUBLE with you engineers is that you fancy yourselves as professional men. Actually, you are just hired help." Matthew Woll's oft-quoted remark still haunts our profession. Faced with employment conditions which appear to lend credence to Mr. Woll's contention, engineers are strongly tempted to say "Let's face it" and to align themselves with his type of organization.

Aren't they jumping to an unwarranted conclusion? After all, who isn't "hired help" in modern industrial society—whether in management, supervision, engineering, sales, accounting, workbench, assembly-line or floor-sweeping activities? Directors hire management, management hires supervision, supervision hires labor, and so on.

Somewhere in our stratified industrial society there is a level below which the employee does not supervise or hire other employees, is not in the confidence of management, is not a part of the permanent organization, is hired and fired according to the level of company activity—in short, is regarded as a commodity. In this category are the workers who may need the services of a union.

How many companies have policies toward their engineers so close to the foregoing conditions as to invite unionization? An engineer employed by such a company must indeed find it hard to fancy himself as a professional man, and if that is what Mr. Woll meant, he had a point.

The current controversy of unionism versus professionalism hinges largely on industrial employment conditions. The engineer, in point of fact, often is so close to the previously defined borderline level that a shift in policy on just one point can swing his thinking in one direction or the other.

Management and engineers share the key. If management treats engineers as a commodity, it can expect a union. If it recognizes engineers as professionals it will inspire a degree of loyalty and dedication to the job which it never dreamed possible.

Engineers can give a big assist to management thinking by orienting themselves toward management's goals. Phil Marvin's thought-provoking article beginning on the next page tells how professionally minded engineers can thus qualify for the status they so ardently desire.

Colin Carmichael

EDITOR

What's the answer to

THE ENGINEER'S

By Philip R. Marvin
Consultant
American Viscose Corp.
Philadelphia

THE high standard of living in the United States has been made possible largely as a result of the efforts of the engineer. He has contributed the products that make this high standard possible. Supplying not only the consumer's immediate needs, he has gone beyond these and pioneered new products for the consumer's enjoyment.

Although engineers have contributed significantly to the advancement of our way of living, a growing number of them are expressing dissatisfaction with their own personal progress. These engineers hold management responsible. Management's attitude appears to be that of open-minded tolerance. Labor leaders claim the problem can be solved through unions.

In the last few years much attention has been focused on the professional side of engineering. Professional development is acclaimed the panacea for the engineer's plight. The camp is still divided. Prounion people are sure they hold the key to the development of greater professional status for the engineer. Antiunion people are just as sure that engineering unions block professional progress. The brightest light on the whole horizon is the apparent interest of the engineers themselves in self-examination of their role.

Too much of the talk about engineering professionalism seems to put the proverbial cart before the horse. In one typical discussion of this subject, the engineers present seemed to be interested only in ways of forcing management to show them greater respect. These engineers wanted to tell management what jobs they would do and what jobs they wouldn't do. They wanted to establish salary brackets based on years of service. All of their energies seemed to be directed at side issues, not basic fundamentals.

When members of another engineering group were asked to explain why they were hired by their employer, it was quite revealing to note that none seemed aware that they were hired to help do a job in the best way, at the lowest cost, and in the shortest possible time.

THE PROFIT MOTIVE

A lot of the fuzziness that surrounds the thinking of many engineers would be cleared away if they would keep in mind that their job is to help earn a profit for the corporation. They should remember that the most valuable engineers are the ones who make the greatest contribution to the overall corporation profit picture. Those who do are well on the way to resolving a lot of problems that bother them daily.

Therefore, the fundamental problem facing the engineer is how to make himself more valuable to the corporation. The value of the engineer grows as he broadens and strengthens his capacity to serve his customer. In most cases the customer for the engineer's services is the industrial corporation.

The engineer is not alone in his concern over the development of his profession. In a very real sense the corporation is equally concerned. For the corporation, the short cut to profits is a sound product. The long costly road is a weak product—with expanded sales effort. Strong product lines are based on sound engineering. Profit building starts in the engineering division.

Since every corporation has one or more competitors, the significance of the engineer's role is projected over the entire industry in which the corporation operates. A company's insurance against annihilation is provided by a vigorous technical program.

Society's stake in engineering development transcends the profit motive. Besides the engineered products that are part of everyday living, the

PROBLEM?

Unionism? Professionalism? Or both at the same time?

This subject is like religion and politics. They are all good topics for debate.

There are no pat answers. This article proposes none. But it does provide

1. **A reflective appraisal of the current attitudes and feelings of many engineers**
2. **A cold analysis of the roles and objectives of engineers and their managements**
3. **A series of recommended actions and policies that can mutually benefit all parties**

complex mechanisms required in national defense are the engineer's responsibility.

MANAGEMENT'S GOALS

Since the engineer, like the lawyer or physician, is a means to an end—not an end in himself—management's goals might well be examined at the outset.

The most important of these goals is the profit goal. Management that doesn't produce a profit doesn't stay around long. The only reason stockholders make funds available to a business is to gain a return on these funds. Management's job is to produce this return.

And this becomes the engineer's job too! Every contribution that he can make toward helping management strengthen the corporation's profit position makes the engineer a more valuable man in the eyes of management and enhances the engineer's role in corporate affairs.

This point isn't always stressed by the people industry sends to the colleges to recruit engineers. To the contrary, some of these recruiters create in the engineer a superiority complex from which some engineers never recover. Perhaps it would be better if they told the potential employee that he has a job to do. He will be in competition with his fellows, and the ones who make the greatest contribution to profits will be advanced in the organization.

Management's second goal is to satisfy customers. This is the basis on which profits are built. Here is where the engineer's training should make him management's right-hand man. He should shoulder full responsibility for the product and for the customer's satisfaction.

Accepting this burden and proving his ability to perform, the engineer assumes one of the key roles in corporate affairs. By applying creative thinking to corporate affairs, the engineer can help lead the corporation.

Management's third goal is to satisfy the employees, and everybody—including the corporation officers — is an employee of the stockholders who put up the money to pay for the men and machinery of the corporation. All employees want more take-home pay and the most pleasant working conditions possible.

Many years ago, Charles E. Wilson, then a vice president of the General Electric Co., championed the statement that a corporation could lift itself by its bootstraps only by providing more goods for more people at less cost. This is as true today as it was then.

All of management's goals can be achieved and have been achieved through better products at lower cost. The opportunities here for engineering contributions are unlimited.

THE ENGINEER'S GOALS

Now let's take a look at the things the engineer says he wants. A survey conducted by a completely independent group revealed the following factors that make a technical role worthwhile:

1. Opportunity to do interesting, challenging, or important work and to have more freedom in or responsibility for one's work.
2. Adequate compensation and economic advancement.
3. Desirable working conditions with respect to equipment, plant facilities, and the handling of service functions.
4. Opportunity to work with competent and congenial coworkers.
5. Opportunity for professional development, advancement and recognition.
6. Opportunity to work under competent supervisors.
7. Control over matters of personal convenience and preference.
8. Development of personal security.
9. Opportunity for advancement based on merit.
10. Adequate number of competent assistants.

It is not too surprising to discover that these are things that most people want. They prove that the engineer is no exception to the general rule.

MANAGEMENT'S RESPONSIBILITY

The engineer's problems find their solution through personal advancement in the organization. Progressive management groups are alert to this. They recognize that long-range profits depend on the steady movement forward of the most capable engineers. The best talent is put to work where it is most needed, and incentive is provided for the top performance.

Here are some of the principal facets of management's responsibility for moving engineers up the ladder:

1. An atmosphere favorable to personal development should be sponsored.
2. Engineers should be evaluated and counseled on a continuing basis.
3. It should be clearly established that there is individual personal responsibility for professional self-development.
4. Stimulants and incentives should be provided.
5. Program assignments to fully utilize available talents should be made and made known.

THE ENGINEER'S RESPONSIBILITY

Focus of attention now shifts to the engineer and the personal requirements that he must satisfy.

First, he must give top performance on his present job. He owes this duty to his employer. This is what he is being paid to do.

Second, the engineer who wants to advance must prove that he is the man best qualified for promotion. This calls for creative talent because he must show how his present job can be done better than it has been done.

Third, he must help and inspire others to do a better job too! Demonstration of leadership is always an essential characteristic that must appear in the makeup of those who are to be given greater responsibility.

It is evident that the engineer who wants to move forward must accept responsibility for his own development, using every possible means that will help him carry out a continuing self-development program.

PROFESSIONAL DEVELOPMENT

The crucial question confronting the engineer who accepts the challenge of self-development is this: How can the job best be accomplished? Our only concern is with the engineer who accepts the challenge—the others are doomed to mediocrity. The decision is strictly a personal one.

Active interest in the engineer's development is being shown not only by management and the unions, but by a number of other organizations as well. The technical professional societies showed an early interest in the subject, publishing articles on engineering management and development as far back as the turn of the century. Trade groups and associations are also devoting time to the engineer and his professional development.

Active sponsorship of the engineer's cause naturally varies in degree and in character, reflecting, as it must, the self-interest of each particular group.

Although individual technical societies have been actively stimulating engineering development, no one society has the membership coverage to do the necessary co-ordinating and unifying job.

Mileposts for the engineer in his self-development have been provided by the standards of professional competency set up by most of the technical societies. Such standards are valuable contributions to the engineer in aiding him to chart his course.

Trade associations have also done their part by keeping the subject of engineering development before their members. Engineering interests have benefited as a result of these efforts. Trade associations, however, have other primary obligations and can't do much more than keep the matter before their corporate members.

EFFECTIVE SELF-DEVELOPMENT

We should be able to look to the past experience of others for help in determining a course of action.

The medical and the legal professions have accomplished results in the direction of professional progress through the American Medical Association and the American Bar Association. Architects are similarly striving for professional recognition

Recommended Grades, Duties, Responsibilities and Qualifications for Engineers

	Scope of Position	Examples of Work Performed	Typical Position Titles
Grade I Preprofessional	Perform routine tasks requiring knowledge of engineering fundamentals related to a particular field of work; work under close and immediate supervision.	Compile data; compute quantities; extend estimates; trace or make simple drawings and sketches; make and record observations and measurements.	Instrumentman, draftsman, detailer, junior engineer.
Grade II Preprofessional	Perform assignments requiring a basic working knowledge of engineering fundamentals related to a particular type of engineering work; usually work under immediate supervision or direction.	Make surveys; make and check quantity estimates or detailed drawings, working from designs by others; inspect minor fabrication, erection, assembly or construction for conformance to plans and specifications; make routine tests and inspections of equipment, materials and processes; set up or operate apparatus or process equipment to obtain technical data; record technical observations and compile results as required.	Junior engineer, party chief, instrumentman, checker, quantity estimator, maintenance or construction inspector; engineering draftsman, laboratory assistant, technical process or equipment tester; assistant instructor or teaching fellow in school of engineering.
Grade III Preprofessional	Perform assignments requiring a basic application of engineering fundamentals to engineering work; under direction but not immediate supervision and having limited responsibility and choice of action affecting design construction.	Select and recommend procedure in design and construction investigations, research, other engineering projects and write specifications or reports for minor projects following established engineering practices or general instructions; perform higher grades of drafting, prepare technical reports and recommendations on minor works.	Junior engineer, senior draftsman, design draftsman, senior inspector, instructor in school of engineering.
Grade IV Professional	Perform engineering assignments under general direction with the requirement for responsibility and choice of action in making decisions and interpretations affecting design or procedures.	Engineering design, select and determine procedure in design, research, surveys, investigations and other engineering practices; write specifications and engineering reports following established engineering practices or general instructions; plan, conduct and report tests of materials, equipment and processes to obtain specified results; effectively recommend acceptance, approval or rejection of materials, fabrication or construction.	Resident, project, office, design, test or process engineer; chief draftsman, chief inspector, research engineer, assistant professor in school of engineering.
Grade V Professional	Perform particularly important engineering work requiring special engineering qualifications or attainments, and offering wide latitude for independent action and decision.	Plan, direct, and supervise the design or construction of major engineering projects; supervise the preparation of specifications and contracts; undertake comprehensive research and investigations; supervise testing work of importance; be responsible for acceptance, approval or rejection of materials, fabrication or construction.	Project, senior office, senior resident, senior design, senior test or process engineer; senior research engineer, assistant division head, associate professor in school of engineering.
Grade VI Professional	Plan, direct and supervise the work of a major engineering unit, or division engaged in design, construction, research, investigations or other technical operations, and usually confined to a particular branch of Engineering.	To manage a small organization or a recognized major division of a larger organization engaged in design, construction, development, research or technical production and limited to a particular field of engineering; to assume professional and executive responsibility for work of division; to give independent critical or expert engineering advice for executive action.	Division or district engineer, production engineer, principal engineer, professor in school of engineering.
Grade VII Professional	Supervise and direct with final administrative authority a relatively large engineering or research organization comprising several divisions.	To determine and establish technical and administrative policies and procedures; to be finally responsible for all engineering research or technical operations of the organization.	Chief engineer, assistant chief engineer, manager of engineering, director of research, department head in school of engineering.
Grade VIII Professional	Supervise and direct with final administrative authority a large engineering or research organization comprising major divisions.	To determine, establish and administer technical and administrative policies and procedures; to be finally responsible for all operations of the organization.	Chief engineer, director of research, dean of school of engineering.

Minimum Education Qualification: May vary to Grade III; graduate in engineering for Grades IV to VIII.

Progressive Engineering Experience: Grade I—None; II—1 year; III—2 years; Grades IV to VIII—Should have not less than 4 years of increasingly important engineering experience and, for the higher grades, added experience indicative of growth in engineering competency and achievement proportionate to responsibilities and duties involved.

Engineering Status: Grades I to III—Registered as engineer-in-training; Grades IV to VIII—Licensed professional engineer.

Ability and Capacity to plan, organize, supervise, and coordinate technical work and to obtain co-operation from others: Grade III—Some; Grade IV—Should be proved for ordinary engineering work; Grades V to VIII—Should be augmented by general administrative ability, with progressive capacity and aptitude in either administration or in positions of research or teaching scientific fields.

—Adapted from *A Professional Look at the Engineer in Industry*, National Society of Professional Engineers, Washington, 1955

through the American Institute of Architects, and they are making steady progress.

These organizations have directed the thinking of their membership toward self-development, both along technical lines and with respect to conduct in the community. They have counseled and guided their members. Their members have greatly profited from this guidance, much of which has been brought out during exchanges of ideas at both local and national meetings. These organizations have not been unions in any sense—there has been no mass bargaining for wages. Group pressure, however, has been brought to bear on many issues of local and national scope, particularly where it was felt to be in the primary interest of the members and of the public.

Organizations like the American Medical Association and the American Bar Association have focused their attention on developing a higher caliber practitioner. In contrast, union leaders dealing with engineering groups are placing emphasis on organized bargaining power. Here are some of the things they want to bargain for:

1. Employer payment of professional society dues
2. Paid time off to attend professional society meetings
3. Tuition refunds
4. Educational and professional leaves of absence
5. Establishment of professional standards

Certainly all of these aims are worthwhile. Management in many corporations has been working toward these goals.

The difference between the approach taken by organizations such as AMA and the approach taken by union leaders is obvious. In the one, improved status is sought through increased competence. In the other, improved status is sought through the bargaining power of pressure tactics.

INITIATIVE—A GROWTH INGREDIENT

One of the very great dangers that lurks along the road to professional development is stifled initiative.

Recently, a young engineer who is quite active in professional activities confided a fear that is also secretly bothering a sizeable number of his colleagues. He has suddenly realized that many professional development programs tend to base advancement on years of practice rather than on individual ability. This engineer wants to move ahead on recognized ability. He doesn't want his future to depend on a formula based on education, years of practice and other such bloodless ingredients. The more active this man becomes in professional development activities, the more concerned he is that his individual efforts will be submerged.

This hazard is a matter of grave concern both to the competent engineer and to management. Growth for both depends on the premiums that stimulate competitive efforts.

PROGRAMMING FOR GROWTH

Three vitally important facets of professional programming emerge.

1. Any course of action should guarantee the individual engineer that rewards will reflect merit. Short of this, in the long run, individual effort will inevitably slacken.

2. Professional development must necessarily combine varying degrees of individual and group development activities and promotional programs.

3. Above all else, the engineer must recognize his unique relationship with management. The engineer's relationship to management is not one wherein a clear separation of interests exists. Management occupies the spot many engineers are aiming for. The engineer's job is to develop his ability to fill posts of greater responsibility if he wants to move ahead. He must do this in a way which does not prejudice his future. The engineer should recognize this aspect in projecting his thinking ahead. He must govern himself accordingly if he is to act effectively in enhancing his professional status.

Management and engineers must give careful attention to each of these points if they are to achieve their mutual goal.

THE ROAD AHEAD

The engineer is right in wishing to forge ahead. At the same time, he must choose carefully the means by which he hopes to achieve his objectives. Mistaken judgment can be costly and time-consuming.

A primary aim of professional development is to gain increased rewards—both financial and prestigewise. The direct approach to these ends is through a professional program designed to develop the full potential of the engineer and to have him show this potential by his performance.

Professional development programs must answer this question: How can the engineer assume greater responsibility for creating better products at lower cost in less time

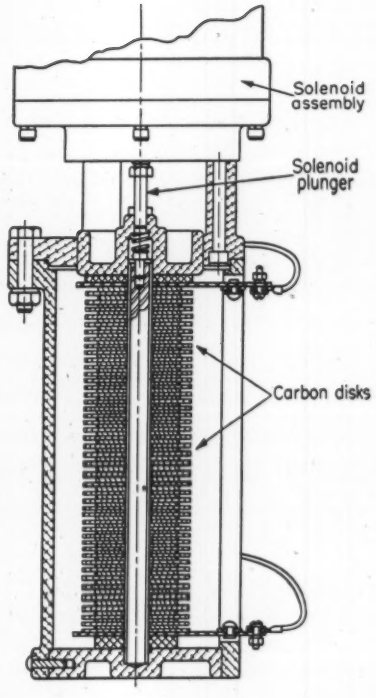
1. By doing a better job on his present assignment
2. By preparing for an assignment of increased responsibility
3. By inspiring associates to achieve higher levels of performance

As ultimate objectives, these points provide the criteria both for program development, and for critical evaluation of proposed programs.

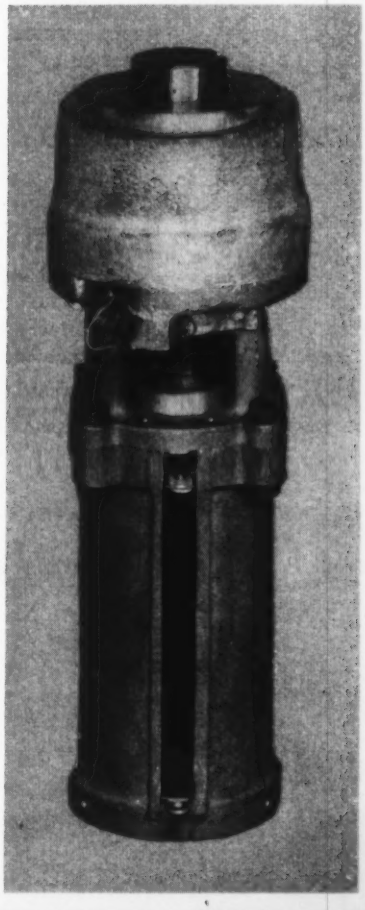
Well, what do you think?

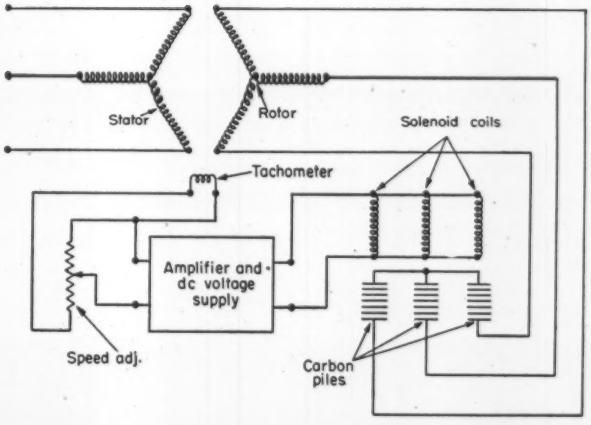
The editors of *Machine Design* will welcome individual comment on this perplexing and vital subject. Your ideas may suggest programs of value to others in the profession. Write to Editor, *Machine Design*, Penton Bldg., Cleveland 13, O.

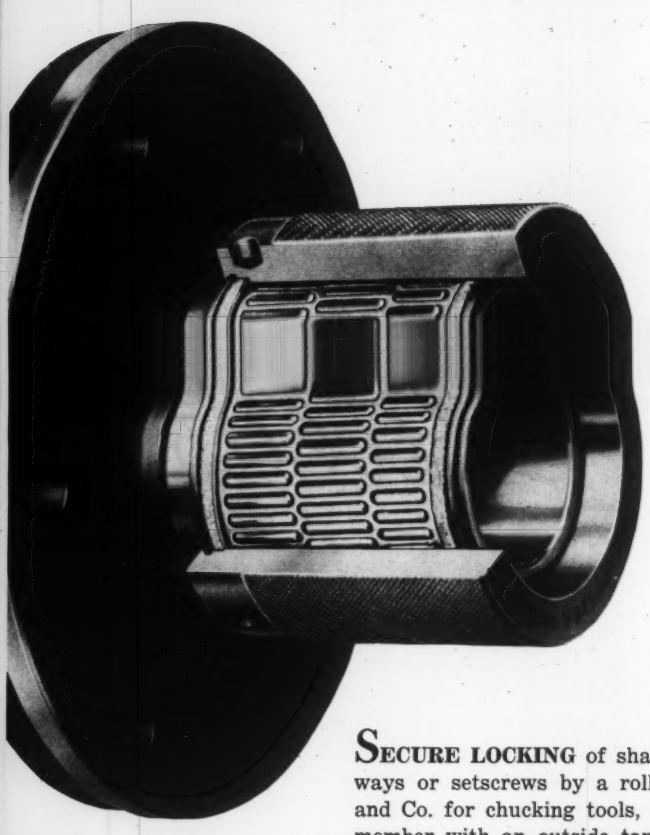
scanning the field for Ideas

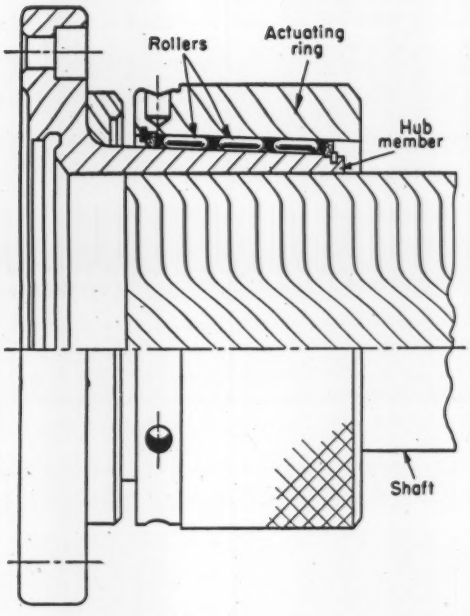


ADJUSTABLE-SPEED CONTROL of electric motors is accomplished by a rugged, continuously variable resistor which has no sliding-contact elements. Used in automatic speed-regulating equipment for ac wound-rotor motors, the controllable-resistance unit developed by Sonic Research Corp. is composed basically of a solenoid and a vertical pile of carbon disks. The assembly is so arranged that pressure on the carbon pile varies directly with solenoid coil current. As pressure on the carbon pile increases, electrical resistance decreases. For some designs, time required to change through the resistance range can be as short as 1/10-second after a control signal is received.





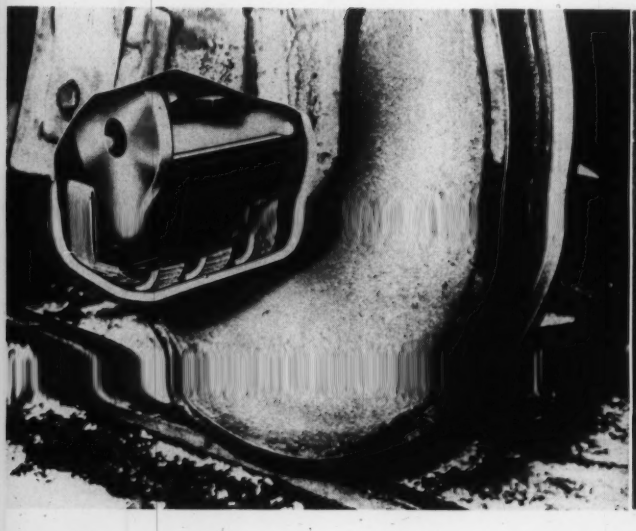


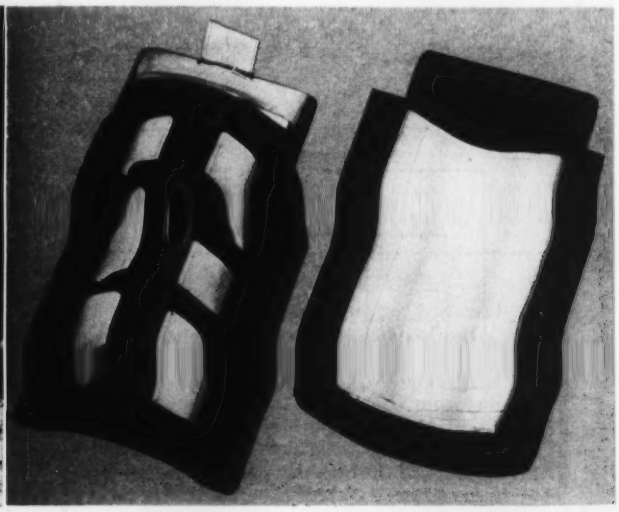


SECURE LOCKING of shaft and hub type members is provided without keyways or setscrews by a roller-wedging technique. Developed by Scully-Jones and Co. for chucking tools, a locking mechanism is composed of an inner hub member with an outside taper, an actuating ring with an inside taper, and a number of rollers located between the tapers. Both tapered surfaces are parallel, and the rollers are cocked at a slight angle to the center line and held in position by slots in a retaining cage.

When the actuating ring is turned clockwise, spiral motion of the rollers forces this ring to move axially, as though it were threaded. A powerful wedging action is created between the tapered surfaces compressing the wall of the inner member against the shaft to provide a secure "shrink" fit. Reverse rotation of the ring unlocks the members.

SPONGE OIL RESERVOIR for journal bearings minimizes overheating problems and functions as an effective oil filter. Developed for use in railroad journal boxes, the design consists of a felt wick pad fitted like a saddle to the top surface of a Neoprene sponge saturated with oil. In operation this felt pad contacts the underside of the journal and serves as an oil wick. At the same time each vertical movement of the journal or journal box compresses the pad assembly, forcing oil upward through holes in the sponge to saturate the felt pad. The sponge acts to retain the lubricant supply in any position of the journal.





FUSES

Factors to consider in matching circuit and fuse characteristics

By John C. Lebens
Chief Engineer
Bussmann Mfg. Co.
St. Louis

ELECTRIC-CIRCUIT protection in machines is all too often regarded as a necessary evil —necessary only to meet safety regulations. Actually, if properly selected and applied, the fuse not only can prevent overloading of machine electric components, such as wiring, motors, resistors, etc., but also can increase machine operational flexibility and reliability. Circuits in all types of machines require electrical protection of a type based on circuit operating characteristics. Complete electrical protection of a circuit can only be realized when the time-current characteristic of the protector matches the safe time-current characteristic of the circuit.

In fusing machines which are driven by electric motors, the controllers and running over-

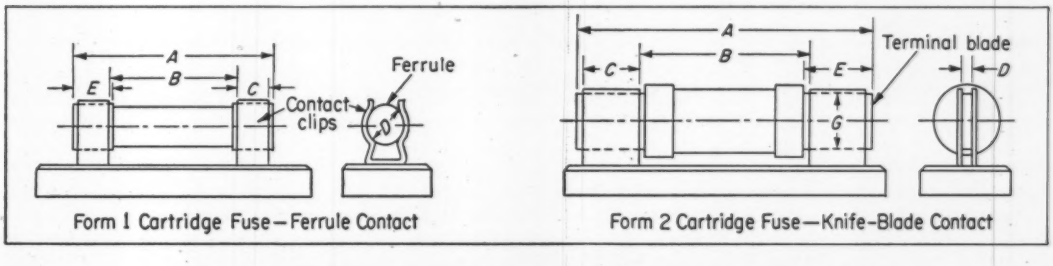


Table 1—Standard Dimensions of Cartridge Enclosed Fuses

Voltage (v)	Rated Cap. (amp)	Fuse Form	A (in.)	B (in.)	C (in.)	D (in.)	E (in.)	G (in.)
Not over 250	0–30	1	2	1	½	9/64	½	
	31–60	1	3	1¾	5/8	13/64	5/8	
	61–100	2	5⅞	4	⅞	½	1	¾
	101–200	2	7⅛	4½	1¼	7/16	1⅜	1⅛
	201–400	2	8⅝	5	1⅜	½	1⅞	1⅝
	401–600	2	10¾	6	2½	¼	2¼	2
Not over 600	0–30	1	5	4	½	13/64	½	
	31–60	1	5½	4¼	5/8	1 7/64	5/8	
	61–100	2	7⅞	6	⅞	½	1	¾
	101–200	2	9⅝	7	1¼	7/16	1⅜	1⅛
	201–400	2	11¼	8	1¾	¼	1⅞	1⅝
	401–600	2	13⅝	9	2½	¼	2¼	2

From Table 34 in the National Electrical Code.

current protective devices for the motors must have short-circuit protection. The recent rerating of motors, which increased the horsepower rating in a given frame size, in effect decreased the thermal capacity of the motor. These motors require controllers with decreased thermal capacity to match the motor characteristics. Hence, both the motor and the controller are more easily damaged by short-circuit currents. These currents must be cut off before they can reach damaging proportions.

The National Electrical Code tries to handle the situation by Article 670 which applies to the electrical equipment for motor-driven, complete metal-working machines, not portable by hand, having one or more tool and work-holding devices used for progressively removing metal in the form of chips. The article permits the use of a 200-ampere fuse at 250 volts and a 100-ampere fuse at 600 volts for short-circuit protection if each motor connected to the circuit has its own running overcurrent protection. This represented the best compromise to an impossible condition with the inadequate protective devices available at the time Article 670 was written. However, the designer of a specific machine tool can furnish better protection with more reliable service by the proper selection of his protective device. In like manner, the designer of any machine can more closely realize optimum operating conditions by proper fuse selection. To do so requires an appreciation of the types and kinds commonly available.

Low-voltage fuses are available in current ratings from 1/500 to 6000 amp with voltage ratings from 32 to 600 and time-current characteristics varying from extremely fast to extremely slow. Also, selection may be made from many different physical sizes and shapes. Each factor must be carefully weighed in the selection of the best fuse for the protection of any given machine.

Fig. 1—Ordinary Edison-base plug fuse, *a*, Type S fuse, *b*, and Type S fuse adapter for installation in Edison-base plug fuse cutouts, *c*

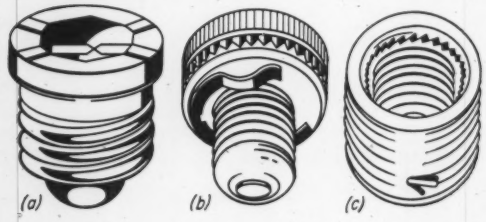
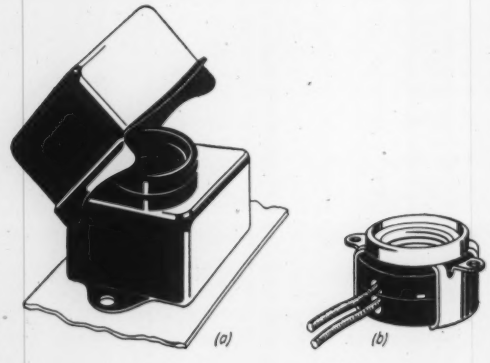


Fig. 2—Receptacles for Type S fuses with housing, *a*, and without housing, *b*



Physical Size of Fuses: The best point of departure in discussing the physical dimensions of low-voltage cartridge fuses is the National Electrical Code. This code establishes the dimensions of cartridge fuses rated at 250 v or less and 600 v or less in a current-capacity range of 0 to 600 amp as shown in *Table* 1. The voltage of a fuse always is given as a maximum and indicates the ability of the fuse to interrupt safely a 10,000-amp dc short-circuit at this voltage.

It is true that the fuse is responsive to current and current alone. However, once it melts and starts to open the circuit, the entire line voltage appears across the fuse and before the circuit is cleared the fuse must extinguish the arc established by this voltage. Obviously, the higher the voltage the greater the arc and the more difficult it is to clear the circuit. For this reason fuses rated at 600 v or less are larger and more expensive than those rated at 250 v or less. The fuse rated at 600 v or less can be used on the 250-v circuit, but it is economically unsound to do so because of the greater cost and size.

In like manner, if the machine limits the short-circuit currents to nominal values, a fuse rated at 250 v or less may give dependable service at 480 v. However, such an application often is undesirable if the machine must pass local inspection, because inspectors frequently will not approve the application even though actual tests prove the safety of the installation.

Plug and Type S Fuses: In addition to the cartridge fuses in ratings from 0 to 600 amp at 250 and 600 v, the National Electric Code describes Edison-base plug fuses and Type S fuses (Fustats) in ratings from 0 to 30 amp. Shown in *Fig.* 1, these fuses are rated at 125 v or less but may be used on 220-v circuits if the voltage to ground does not exceed 150 v. Type S fuses may be installed in Edison-base plug fuse cutouts by inserting an adapter, *Fig.* 1*c*, in the cutout which, once installed, cannot be removed. This adapter prevents a 30-amp Type S fuse from being inserted in a 15-amp circuit thereby preventing the insertion of an oversize fuse.

Receptacles, specifically designed for Type S fuses, also are available for mounting directly on the machine, *Fig.* 2. Where the receptable can be incorporated in the machine housing a simple receptacle such as shown in *Fig.* 2*a* can be used.

Otherwise, a more expensive receptacle of the type shown in *Fig. 2b* is required.

Small-Dimension Fuses: The NEC fuses and Type S fuses of the proper characteristics will protect machine circuits adequately, but in many cases there is not sufficient room for them. For this reason many different types of small-dimension fuses have been developed so that maximum protection can be furnished in the minimum space. For example, 20-amp fuses rated at 250 v or less are available in dimensions as small as ¼-inch in diameter and 1¼ inches long. This is quite a reduction from the NEC 20-amp fuse having dimensions of 9/16-inch in diameter and 2 inches long. Even more important, the small-dimension fuses can be installed in fuseholders of the type shown in *Fig. 3*; these greatly simplify the problem of installation and reduce the space requirements. This fuseholder also is available with a test prod hole in the knob to provide a convenient test location for checking both the circuit and the condition of the fuse. Then, too, it can be supplied with a lamp in the knob which indicates whether the fuse has blown if the circuit remains energized.

If improper fuse replacement is a problem, small-dimension fuses and fuseholders which prevent the insertion of the wrong size or type of fuse can be specified, *Fig. 4*. The two ears on the top cap of the fuse pass through slots in the top cap of the corresponding fuseholder, and the fuse is locked in position by a quarter turn. Contact pressure is maintained by a coil spring in the bottom of the fuseholder. By varying the width of the slots and the length of the fuse many separate and distinct combinations are available. Hence, it is impossible to replace a blown fuse with one of the wrong type or larger rating, thereby assuring adequate protection throughout the life of the machine. This feature is particularly important where the fuse replacement is beyond the control of the machine manufacturer and may be made by untrained personnel. It was developed to meet the requirements of television receiver protection but is applicable to any machine where the hazard of shock is not a factor. Since the projecting fuse cap is uninsulated, the fuse must be used on a low-voltage circuit or inside an interlock to prevent contact when the circuit is energized.

Time-Current Characteristics: Under normal, satisfactory operating conditions, the current can vary within extremely wide limits without injuring the machine electrical components as long as the current is not permitted to flow longer than a predetermined safe-time. Under faulty operating conditions these same currents are maintained long enough to damage, if not destroy, the circuit components. The difference between safe and faulty operation at any load is a matter of time. If the current is cut off before damaging conditions are reached, a component such as a motor is not being operated at its full capacity, whereas if the current is allowed to flow too long, the component is destroyed. Hence, for complete protection, the time-current characteristic of the fuse must be matched to the safe time-current characteristic of the electrical circuit or circuits involved. Otherwise, little more than short-circuit protection results.

The safe time-current characteristic of electrical equipment is a function of three factors—the current-conducting path, the electrical insulation, and the heat-absorbing mass. At low overloads which can be withstood for relatively long periods, there is time for heat conduction. Under this condition the temperature of all parts of the machine is raised by the heat generated in the current conducting path. The rate at which the temperature is increased is inversely proportional to the mass

Fig. 3—Typical fuseholder for small-dimension fuses. Unit is for ¼ by 1¼-inch fuse and has an overall length of 2 9/32 inches

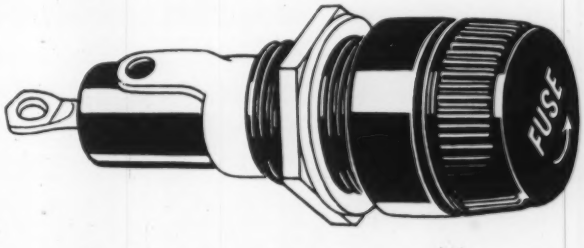
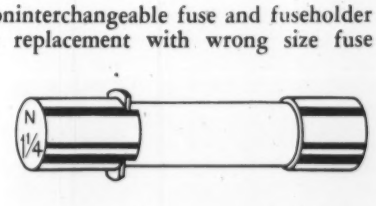
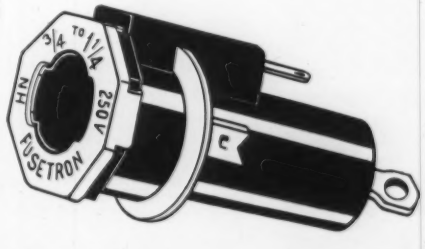


Fig. 4—Noninterchangeable fuse and fuseholder to prevent replacement with wrong size fuse





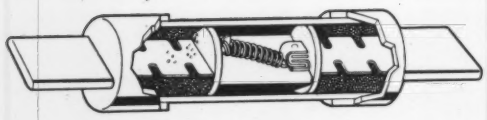


Fig. 5—Dual-element fuse

of the heat-absorbing member and to the amount of heat lost by radiation and convection, and directly proportional to the amount of heat generated. The current-conducting path, the electrical insulation and the heat-absorbing mass heat up as a unit and failure occurs when the damaging temperature of the least heat-resistant material is reached. This usually is the electrical insulation.

Since the heat generated is proportional to the square of the current, the safe time of the motor steadily decreases as the current is increased, the shape of the safe time-current characteristic being approximately a square-law curve. The curve actually varies from a true square law curve by a factor unique for each machine dependent on its thermal conduction, radiation, and thermal capacity.

As the current is increased, a point finally is reached where the heat generated in the electrical path is so great that it melts before little or any of the heat can be conducted from it. At these very high overloads an extremely short safe time results. There is little time for thermal conduction so that the heat absorbing mass is that of the wire itself. Hence, the shape of the safe time-current characteristic curve at these overloads is a square-law curve having an extremely steep slope.

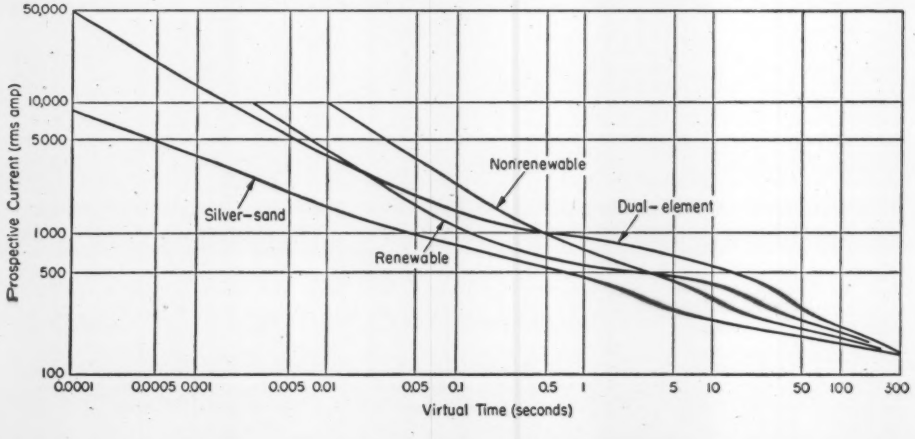
Thus, the safe time-current characteristic of all electrical units such as motors and generators is a composite curve consisting of two square-law curves having different slopes because of the different thermal capacities. At the point where the two curves meet a point of inflection results. At this point the type of failure changes. At currents below this point the failure occurs in the insulation and at loads above this point the failure occurs in the wire itself.

Dual-Element Fuses: For protection of electric motors, the dual-element fuse (Fusetron) is often used. As shown in *Fig.* 5, it consists of a short-circuiting strip surrounded by arc-quenching filler in each end of the fuse with a thermal overload device in the center. The short-circuiting strips are relatively insensitive to ambient, whereas the thermal-overload device responds to ambient in the same manner as the insulation in the motor.

Current flowing through the fuse generates heat in the short-circuiting strips. At the lower overloads, where there is time for thermal conduction, the heat is conducted into the thermal overload device in the center of the fuse and this raises its temperature until 280 F is reached. At this point the fusible alloy melts, permitting the interrupter to move mechanically under spring tension to open the circuit. At the higher overloads, where there is not sufficient time for thermal conduction, the heat generated in the reduced sections in the short-circuiting strips raises their temperatures to the melting point causing them to function like ordinary fast-acting fuses. Use of copper and copper alloys for the short-circuiting strips permits the mass to be reduced to less than that of the ordinary fast-acting fuse. Thus the operation of the dual-element fuse on heavy short-circuit currents is faster even though it will hold the useful loads for periods of time much longer than possible with the fast-acting fuse.

Fuse Characteristics: The time-current characteristics of the dual-element fuse, the renewable (Super-Lag) fuse, the ordinary nonrenewable fuse, and the silver-sand fuse are illustrated in *Fig.* 6. For the purpose of comparison fuses rated at 100

Fig. 6—Comparison of time-current characteristics of four types of 100-amp 250-v fuses



amp and 250 v were selected. The characteristics vary somewhat with the different ratings, but these curves are representative and give a good picture of the relative characteristics. All four fuses are capable of carrying 100 amp continuously and will open at 135 amp in approximately the same time. However, from this common starting point the characteristics of the four fuses diverge as shown. The ordinary nonrenewable fuse, having relatively little thermal capacity and only one mode of operation, has a smooth time-current characteristic without any points of inflection. It has little time-lag at the lower overloads so that it will open on harmless transients caused by the machine starting or by momentary overloads on it. Even so, it is the slowest of all four fuses under short-circuit conditions.

The renewable fuse, with its increased thermal capacity, has longer time-lag than the nonrenewable fuse at the lower overloads, but the effect of the increased mass is lost above 300 per cent load. Hence, it represents little improvement in the protection of motor-operated machines because such machines produce harmless transients which would blow either the nonrenewable or renewable fuses if their rating were selected equal to the rating of the machine. For this reason such fuses usually are selected equal to three or four times the full-load rating of the machine and furnish only short-circuit protection.

Since the mode of operation of the renewable fuse changes with the overload, the curve contains a point of inflection and its opening time under short-circuit conditions is less than that of the nonrenewable fuse.

As shown in *Fig.* 6 the dual-element fuse has more than 10 seconds at 500 per cent load. This is adequate to eliminate needless blows on harmless overloads even if the fuse size is selected equal to the full-load rating of the machine. Since dual-element fuses are available in cartridge sizes as established by the National Electrical Code and in Edison-base, Type S and small-dimension fuse sizes, the designer can select the proper type for his application.

Short-Circuit Protection: Designers are often required to select fuses for short-circuit protection. In some cases the size of a motor in a machine may require a heavy electrical circuit capable of furnishing as much as 100,000 amp under short-circuit conditions. In other cases the motor, even though relatively modest in its electrical demands, may be connected to a high-capacity bus which may permit heavy fault currents to flow.

If the circuit is protected by fuses, short-circuit currents will be limited, if circuit breakers are used, the full available fault current will flow before the circuit breaker operates. Under such conditions the fuse in the circuit must operate to protect it from the short-circuit currents. If the conductors are too small, the current may melt them.

Fortunately, the inherent design of most components such as motors prevents heavy short-circuit currents from flowing. The impedance introduced by the external wiring usually is sufficient to reduce the fault currents to a nominal value so that even a direct short-circuit at the point the circuit enters the machine will produce currents ranging from 100 to 1000 amp. These certainly are not difficult to clear without danger by ordinary nonrenewable or renewable fuses.

However, where heavy short-circuit currents are possible, either the dual-element fuse or the silver-sand fuse should be used. Recently the silver-sand fuse has gained favor in the United States for the protection of high-capacity circuits against heavy shorts. It consists of a silver link embedded in quartz sand filler.

As shown in *Fig.* 6 the silver-sand fuse has less time lag than the ordinary nonrenewable fuse so that it cannot furnish overload protection. However, its fast action on short-circuit cuts the currents off before they can build up to the available amperes. For this reason the current axis is labeled "Prospective Current" and the time axis "Virtual Time" in *Fig.* 6. The prospective current is the current which would flow if not limited by the blowing of the fuse; it is the available amperes of the circuit. The virtual time is the time the prospective current must flow to produce the same heating effect in the circuit as that produced by the current flowing while the fuse is blowing. For times longer than 0.01-second the prospective current is the same as the actual current flowing, and the virtual time is the same as the actual time. However, for times shorter than 0.01-second the concept of prospective current and virtual time must be used because the fuse blows before the current can build up to the available amperes.

Fig. 6 shows the silver-sand fuse is fastest in the short-circuit region and therefore limits the short-circuit currents most. However, it is not reasonable to make a comparison on the same current rating basis because in the protection of any machine the silver-sand fuse rating must be selected at least three times that of the dual-element fuse. In other words a machine which could be protected by a 30-ampere dual-element fuse would require a 100-ampere silver-sand fuse so that the current limitation under short-circuit conditions of the 100-ampere silver-sand fuse must be compared with that of a 30-ampere dual-element fuse. Such a comparison shows little difference between the two.

Hence, the dual-element fuse offers interesting possibilities in the protection of electrical circuits but the protection of each circuit in a machine should be studied in the early stages of the development so that the best type, size, and characteristic can be selected and sufficient space provided. Only then can the best protection be obtained in the minimum space and at minimum cost.

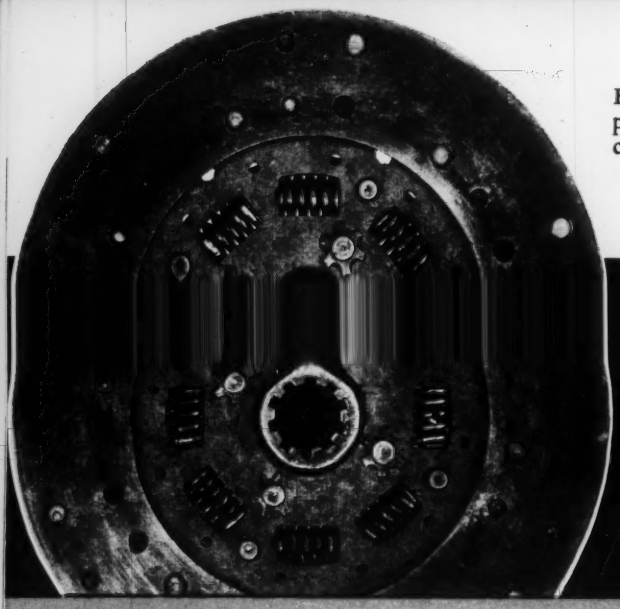


Fig. 1—Left—Single-plate, double-faced clutch design for automotive applications

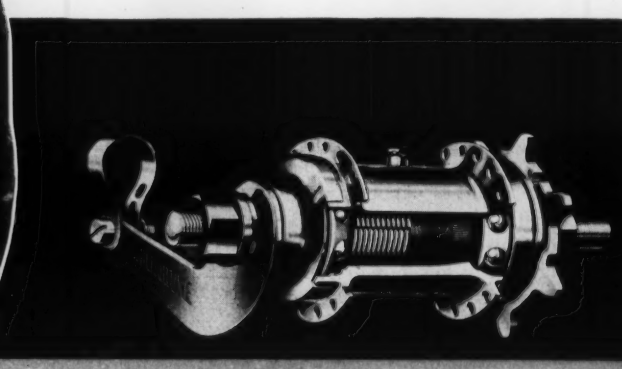


Fig. 2 — Multiple-disk bicycle coaster brake employing eleven double-faced bronze friction disks and matching steel faces

Multiple-Disk Clutches and Brakes

By Howard B. Huntress *Research Engineer, Research Center*
American Brake Shoe Co., Mahwah, N. J.

FRICTION clutches and brakes of the disk type vary widely in size, design and performance characteristics. A basic arrangement is exemplified by the rugged single-plate, double-faced automobile clutch, *Fig.* 1. This design is characterized by its spring-loaded mechanism, and its two opposing friction faces: cast-iron flywheel on one side and cast-iron pressure plate on the other.

When this same principle is extended to include more than one double-faced disk, a multiple-disk mechanism is produced, *Fig.* 2. In this case, the friction disks, which are splined to the same shaft or hub, are matched by an equal number of additional opposing faces in an assembly that can be compressed axially to engage all of the contact surfaces.

For its size, the multiple-disk mechanism is one of the most effective and powerful devices for control of friction forces. Capacity of units may readily be varied by increasing or decreasing the number of active friction disks. As a result, low-friction materials can be utilized since the torque of a single disk can be multiplied to match operating load requirements. Moreover, because of the large surface contact area provided, rate of wear is comparatively low.

Range of Application

Probably the most common multiple-disk friction device in every-day use is the bicycle coaster brake, Fig. 2. Although this mechanism is only about 1 in. in diameter, it is capable of transmitting sufficient torque to lock the rear bicycle wheel with a large man aboard. The great torque capacity of the bicycle brake stems from the multiple-disk design.

While a bicycle brake is among the smallest of the multiple-disk mechanisms, brakes on the wheels of earth-moving tractors are among the largest, *Fig.* 3. These brakes consist of disks about 23 in. in diameter, each disk carrying 100 sq in. of friction material on each side. The various types of vehicles carry from three to seven such disks in each of the wheels.

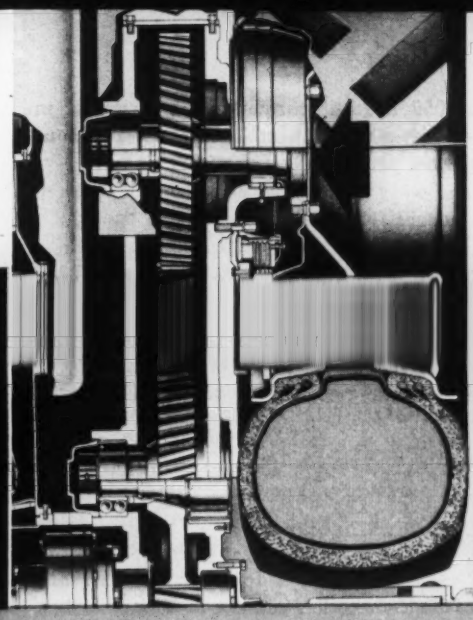
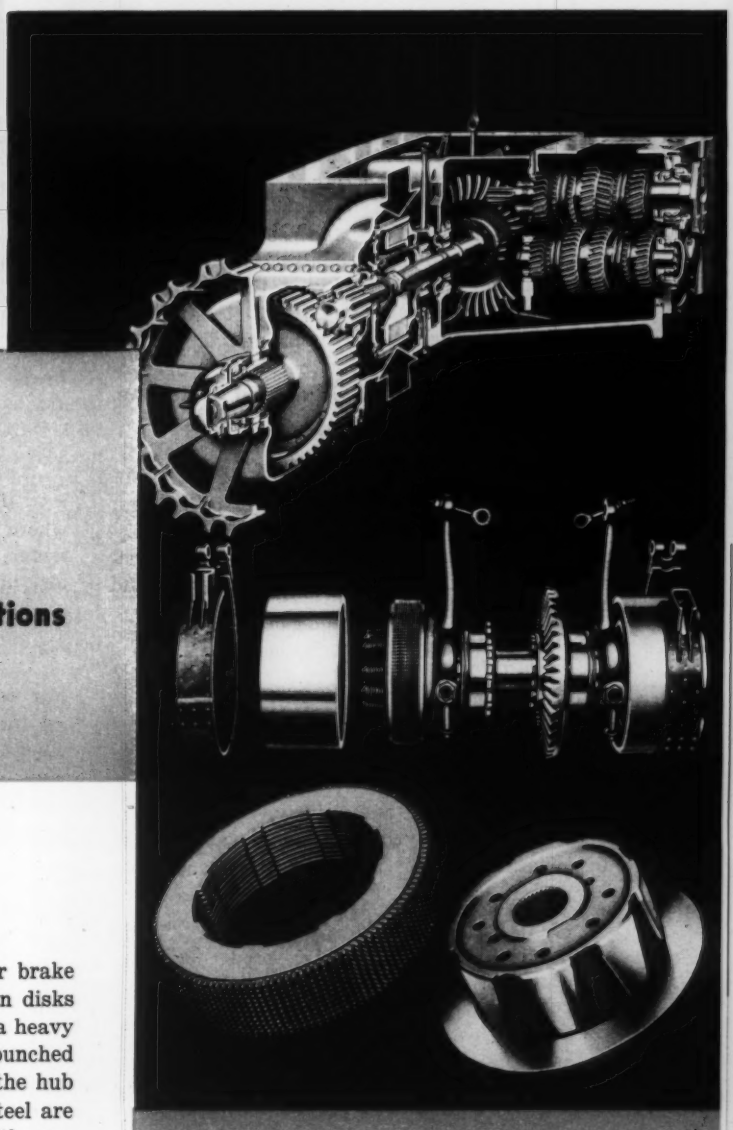


Fig. 3—Earth-moving tractor brake which uses friction disks of 23 in. diameter to provide high braking torques. Brake engagement is hydraulically controlled

Fig. 4 — Below — Multiple-disk tractor steering clutch in which friction disks are 16 in. diameter. Each disk can develop 1000 lb-ft braking torque



- **Application factors**
- **Torque relationships**
- **Mechanical considerations**
- **Wet clutch design**

Friction forces can be controlled by a number of methods. Of major importance in design are the various friction clutch and brake units which provide a wide range of characteristics. In this third article of a group dealing with friction and its effects, attention will be devoted to the multiple-disk friction devices and the factors influencing their application and design.

Earlier articles have treated the nature of friction and its effects (July 1955) and sintered-metal friction materials (November 1955). Other subjects to be covered include nonmetallic friction materials and basic theory of clutch and brake operation.

The principle of the multiple-disk tractor brake is the same as that of the bicycle. Friction disks consist of two faces of friction material on a heavy steel core which has regular spline teeth punched on the circumference. These teeth engage the hub or drum of the wheel. Opposing disks of steel are keyed to a drum attached to the body of the vehicle. In this application, a hydraulic cylinder applies the compressing force to engage the multiple disks.

Between the extremes of the bicycle brake and the tractor brake, there are many intermediate sizes and shapes used in multiple-disk brakes and clutches. Some are dry friction mechanisms and some are bathed in oil. The number of disks may vary from few to many, and the disks are generally thin and of narrow face.

As an example of the high-torque capacity of the multiple-disk design, a double-faced, 16 in. diameter clutch disk at a pressure of 50 psi will transmit a torque of over 1000 lb-ft. In an application such as a tractor steering clutch, *Fig.* 4, this torque may be multiplied by a factor of 18. The total thickness of the 18 clutch disks and the 19 mating plates would be only about 5 in.

In another high-speed, heavy-duty braking ap-

plication, a 14 in. diameter, double-face disk, *Fig.* 5, under a pressure of 50 psi transmits a torque of 500 lb-ft. A ten-disk brake would therefore transmit 5000 lb-ft of torque. Such a brake, in a 40 in. diameter wheel, would decelerate five tons at 10 ft per sec per sec.

Torque Relationships

As an approach to the design problems associated with a multiple-disk mechanism, it is necessary to establish the relation between the dimensions of the disk, the pressure applied to the friction surfaces, the coefficient of friction and the torque developed. The expression for the torque transmitted by a double-faced disk is derived as follows, using *Fig.* 6 as a reference.

For a single friction surface,

$$d\tau = 2\pi\, p\mu\, r^2 dr \quad \ldots\ldots (1)$$

where $d\tau$ = incremental torque developed, lb-in.; p = normal pressure applied to the friction surfaces, psi; r = effective radius, in., of the normal force acting on the incremental area $2\pi r dr$; and μ = coefficient of friction.

For a double-faced disk.

$$d\tau = 4\pi\, p\mu\, r^2 dr \quad \ldots\ldots (2)$$

By integration,

$$\tau = \frac{4\pi\, p\mu}{3}\,(R_o^3 - R_i^3) \quad \ldots\ldots (3)$$

where R_i and R_o are, respectively, the inside and outside radii, in., of the friction surface.

In general practice, the total force acting on the friction surfaces is known. By definition,

$$p = \frac{P}{A} = \frac{P}{\pi(R_o^2 - R_i^2)} \quad \ldots\ldots (4)$$

where P = total applied force in pounds, and A = area of the friction surface in square inches. From Equation 3 then, substituting for p,

$$\tau = \frac{4P\mu}{3}\left(\frac{R_o^3 - R_i^3}{R_o^2 - R_i^2}\right) \quad \ldots\ldots (5)$$

A simplified form of this equation is:

$$\tau = 2P\mu G \quad \ldots\ldots (6)$$

where G, which may be referred to as the geometry factor, remains constant for a specific multiple-disk unit and is given by

$$G = \frac{2}{3}\left(\frac{R_o^3 - R_i^3}{R_o^2 - R_i^2}\right)$$

For convenience, a graph giving values of G for all inside and outside diameters up to 24 in. is shown in *Fig.* 7.

Clutch Design: A basic consideration in the design of a clutch unit to meet specific limiting dimensions is how to obtain the best balance between maximum torque capacity and effective operating life. Friction materials are expensive and the fact that space allotted to clutch mechanisms is usually

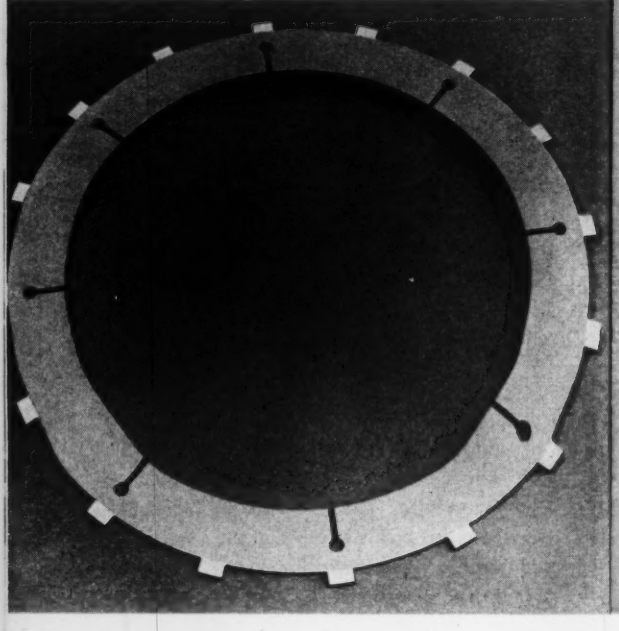
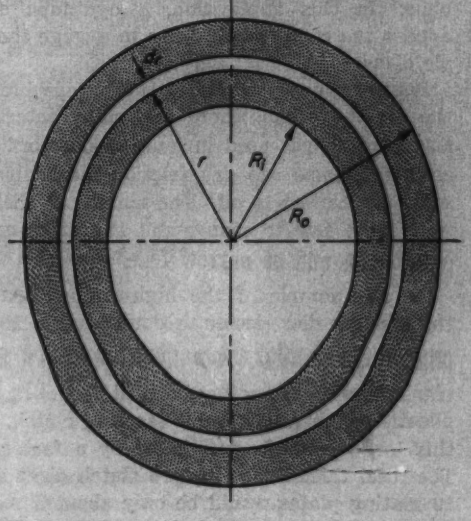


Fig. 5—Double-faced, 14 in. diameter friction disk for high-speed heavy-duty unit. Disk will develop 500 lb-ft braking torque under 50 psi pressure of engagement

Fig. 6—Symbolic notation for analysis of friction disk torque relationships



small accentuates the problem of reducing wear to a reasonable level.

For a particular application, the following design information will usually be available: (1) torque to be transmitted; (2) limiting dimensions, or maximum outside diameter, of the clutch unit; and (3) pressure with which the clutch plates may be engaged. One other point that may also be predetermined is whether a single-disk construction must be used or a multiple-disk mechanism is permissible.

In certain applications, it may be found that standard friction materials do not provide sufficient torque capacity. Possible methods of overcoming this problem include the use of material with a higher coefficient of friction or increased plate pressure. However, another expedient is available by which the torque transmitted can be increased without either of these changes. That is by increasing the inside diameter of the friction surfaces. With this approach, however, increased torque is obtained at the sacrifice of wearable material, and the life or durability of the friction disks will suffer.

It can readily be shown by mathematical analysis that the torque developed by a narrow friction ring whose ID approaches its OD is nearly 1.5 times that delivered by a solid disk with the same OD, but with ID = 0. Obviously there is no durability in a clutch where the ID approximates the OD. Durability increases as ID shrinks and becomes greatest when this dimension approaches zero. The greater the volume of material available at the friction surfaces, the longer the operating life. The relationship of area to ID, for a given OD, is

$$A = \pi \ (R_o^2 - R_i^2) \qquad (7)$$

If $a = R_i/R_o$, then

$$A = \pi R_o^2 \ (1 - a^2) \qquad (8)$$

Also, from Equation 6, for a single-face clutch disk,

$$T = P\mu G = \frac{2}{3} \mu P R_o \left(\frac{1 - a^3}{1 - a^2} \right) \qquad (9)$$

In Equation 8, area is largest ($A = \pi R_o^2$) when $a = 0$. When $a = 1$, $A = 0$. As pointed out previously, torque developed by a narrow friction ring is 1.5 times that of a solid disk. Thus, while torque

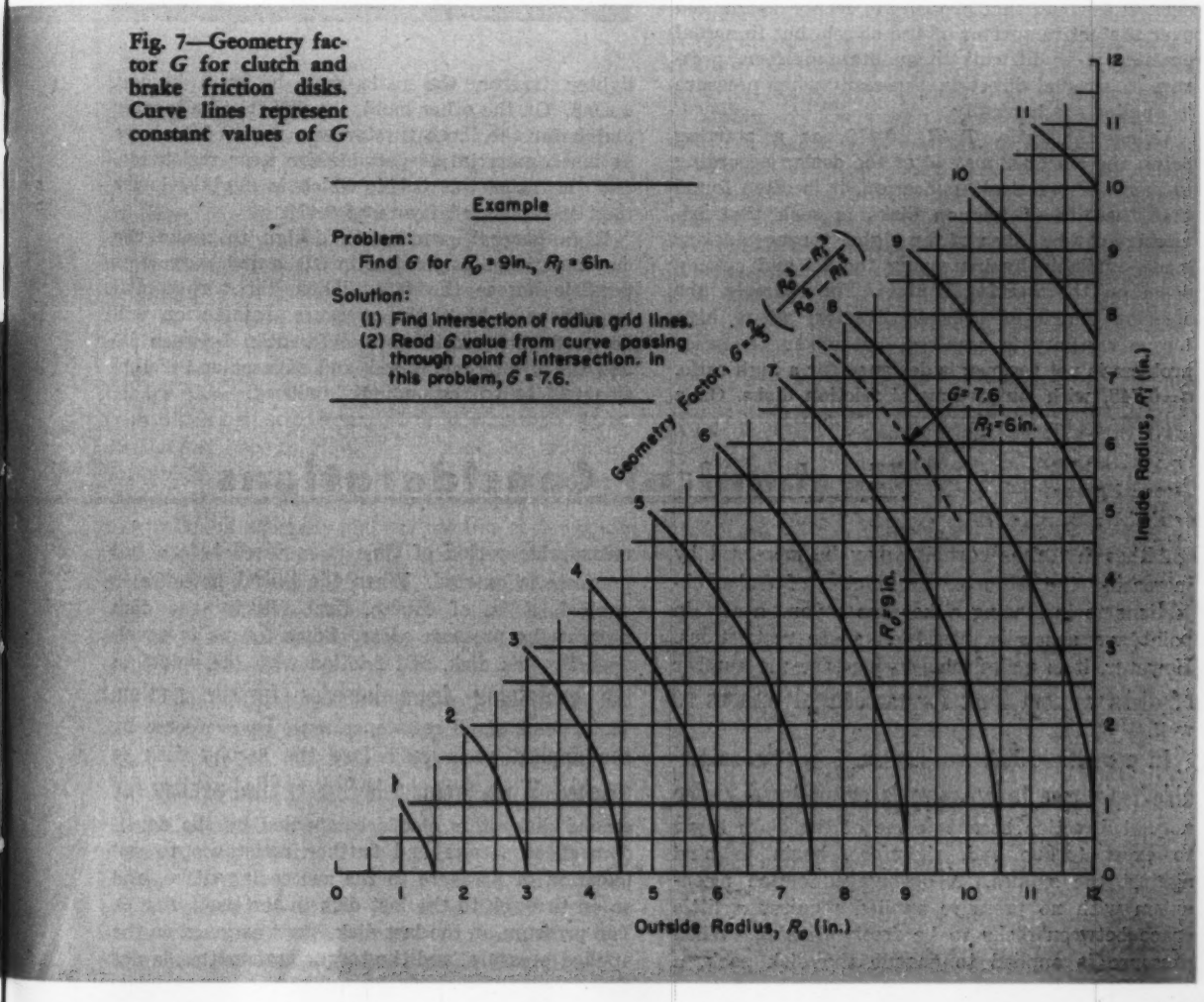

Example
Problem:
Find G for R_o = 9in., R_i = 6in.
Solution:
(1) Find intersection of radius grid lines.
(2) Read G value from curve passing through point of intersection. In this problem, G = 7.6.
Geometry Factor, $G = \frac{2}{3}\left(\frac{R_o^3 - R_i^3}{R_o^2 - R_i^2}\right)$
G = 7.6
R_i = 6in.
R_o = 9in.
Inside Radius, R_i (in.)
Outside Radius, R_o (in.)
0 1 2 3 4 5 6 7 8 9 10 11 12

Fig. 7—Geometry factor G for clutch and brake friction disks. Curve lines represent constant values of G

varies from 1 to 1.5, or from 2/3 to 1, durability drops from 1 to 0. These area and torque relationships are plotted in *Fig.* 8. The equation of the area curve is

$$y = k\,(1 - a)^2 \qquad (10)$$

For the torque curve,

$$y = \frac{2}{3}\,k\left(\frac{1 - a^3}{1 - a^2}\right) \qquad (11)$$

At the intersection of these two curves, the values of y are identical, giving the point at which equal emphasis is placed on torque capacity and life. Setting Equations 10 and 11 equal, and solving, gives

$$a^4 + \frac{2}{3}\,a^3 - 2a^2 + \frac{1}{3} = 0 \qquad (12)$$

Trial and error solution of Equation 12 gives the intersection of the two curves as $a = 0.47936$. Thus, if equal importance is assigned to durability and torque output, the ID of a clutch should be 0.47936 times the OD to derive the greatest life for the greatest torque output.

Torque and wear are not the only considerations in the design of friction disks. The previous discussion assumes that pressure is evenly distributed over the entire surface of the clutch, but in actual practice it is difficult to maintain uniform pressure in a radial direction, especially when pressure is applied mechanically.

Using the ratio, $R_i/R_o = 0.479$, as a starting point, the designer may alter the design according to need. In practical application, it is often found that the life of friction disks is such that advantage can be taken of the higher torque capacity made available by increasing the ID and cutting down on the wearing surface. For example, the steering clutch of a heavy tractor, where high torque capacity is required, but where the wear problem is not serious, is designed for a high ratio, $a = 0.748$, with sintered-metal friction disks. On a lighter tractor, the ratio may be even higher, $a = 0.8$. On the other hand, the dry friction master clutch for the large tractor was required to have as much material as possible for wear resistance, and the ratio was 0.444, which is slightly lower than the balanced figure of 0.479.

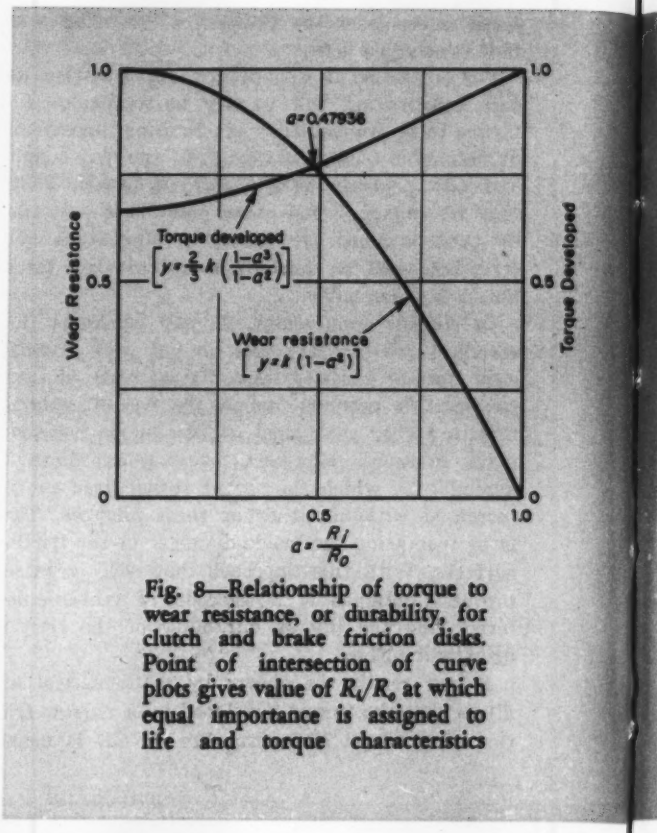


Fig. 8—Relationship of torque to wear resistance, or durability, for clutch and brake friction disks. Point of intersection of curve plots gives value of R_i/R_o at which equal importance is assigned to life and torque characteristics

It is general practice in design to make the clutch as large as possible in OD and as narrow as possible across the face. Thus, the torque will be relatively high, the pressure distribution will be good, the temperature differential between ID and OD will be minimized, and stresses and distortion will be correspondingly reduced.

Mechanical Considerations

Although torque capacity may be increased by increasing the diameter or number of disks, objections to increasing either one beyond a certain point are generally based on space restrictions. However, it is undesirable to increase the number of disks without limit for mechanical reasons as well.

In a multiple-disk mechanism, *Fig.* 9, considerable resistance to pressure is encountered in the normal direction because some of the disks begin to exert torque and, therefore, begin to bind against the splines. A disengaged clutch mechanism with no pressure applied requires a little space between disks to be freely turning. When pressure is applied to engage the disk pack, a measurable period of time is required before full pressure is exerted. When the initial pressure is applied, it is, of course, first felt by the disk nearest the pressure plate. Some torque is developed by this disk, and friction with the spline in the containing drum impedes further motion. Thus, some small resistance must be overcome by the applied pressure before the second disk is reached. When pressure is first applied against the second disk, it is also accompanied by the development of torque and further resistance to application of pressure to the succeeding disks, and so on through to the last disk in the pack, *Fig.* 9. The pressure on the last disk is not as great as the applied pressure, and the torque transmitted is not

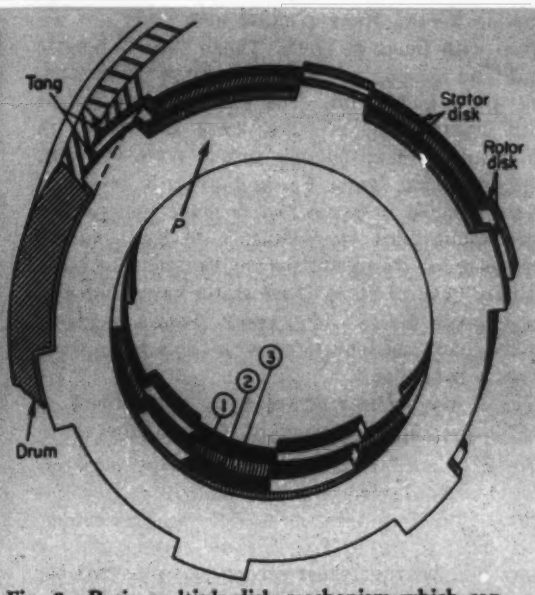


Fig. 9—Basic multiple-disk mechanism which can be used for analysis of spline friction phenomenon. When pressure *P* is applied to rotor disk 1, friction between disks 1 and 2 produces torque of rotor disk against drum. Friction between drum spline and tang of rotor disk resists axial motion of disks 1 and 2, reducing pressure applied to rotor disk 3, and succeeding disks in the pack

as great as that computed on the basis of the applied pressure.

An extreme example is found in the cross-drive transmission of crawler type vehicles where the steering clutches are so geared that it is possible to have a relative velocity between driving and driven elements as high as 8000 rpm. To employ many disks in these clutches would be impractical because of the binding of the tangs. Therefore, they are designed for only four disks which transmit sufficient torque for the application.

At the opposite extreme is the earth-moving tractor steering clutch. The main function of this type of clutch is to transmit static torque. It is disengaged only to allow a brake on the tread to be applied momentarily to change the direction of tractor motion. When direction has been changed, the brake is released and the clutch re-engaged. Just before re-engagement, the speeds of the driven and driving members are practically the same, and it is possible for the whole assembly of disks to receive pressure before measurable torque can be developed by any one disk. Under these condtions, there is no objection, mechanically, to a large number of disks and use of 10 to 20 disks per clutch is common practice.

From the practical point of view, however, tractor clutches are abused by failure to completely disengage the clutch before applying the brake. Therefore, the steering clutch no longer can be classed as static, for it is forced to slip under pressure. Spline friction is manifested by differences in wear between the front and back plates. The wear itself is further proof that energy is absorbed by the tractor clutch.

Despite the conflict between theoretical and practical aspects of clutch technology, it is possible to generalize that when a clutch is intended for static use and high static torque is required, a large number of disks may be used. However, when the clutch is for high-speed dynamic use, the number of disks should be as small as possible.

Thickness of Components: After a suitable diameter and number of disks have been determined, thickness is the next consideration. Two dimensions are necessary for specification: one is the thickness of the steel core and the other the thickness of the friction material face.

The diameter of the disk governs the thickness of the steel core. For example, sintered-metal disks of small diameter, 3 to 6 in., should have a core thickness of about 0.028 to 0.034-in. Disks of 6 to 12 in. diameter should have a core thickness of about 0.062-in. For diameters of 12 to 16 in. the core thickness should be about 0.090-in., and above 16 in. the core thickness should be about $\frac{1}{8}$-in. This relation between core thickness and disk diameter is approximately linear, *Fig.* 10.

Sintered-metal friction disks need not be thick. When the application is in oil, the friction material may be quite thin because the normal wear rate in oil is extremely low. Moreover, it is desirable to design for low wear because multiple-disk devices are limited in the amount of possible take-up adjustment of the pressure mechanism. The usual thickness of wet-friction sintered-metal faces, for example, is 0.015 to 0.040-in.

While friction materials wear faster in dry than in wet applications, the same limitations on thickness apply. In parts like the tractor steering clutch, where energy absorption is small, the faces can be made quite thin, and little wear would

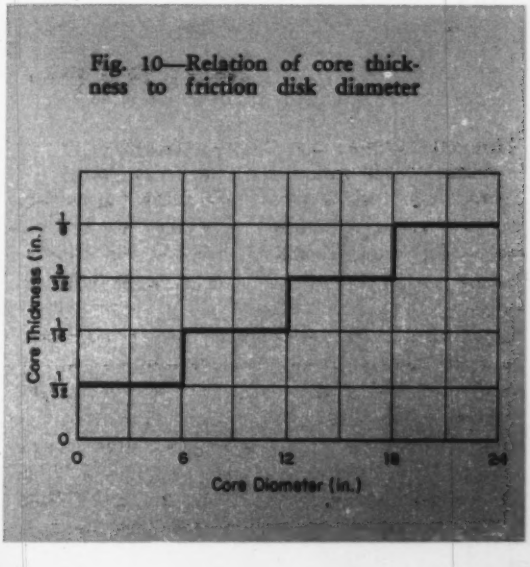


Fig. 10—Relation of core thickness to friction disk diameter

be expected. This is actually the case, and such clutches are slow wearing. In aircraft brakes, the limit of allowable wear is associated with the limit of pressure application adjustment, and the faces are very thin—on the order of 0.020-in. In clutches or brakes employing a small number of disks, the friction faces may be thicker and, where single disks are used, the friction material may be as much as ¼-in. thick.

The single clutch disk is used widely as an engine clutch and, in contrast to the double-faced, splined disk, is constructed by riveting two single-faced, steel-backed friction disks to the sides of a steel web disk, which in turn is fastened by rivets to a splined hub. The diameter range of this composite type clutch is from 10 to 18 in. When mettallic friction materials are used, friction surface thickness ranges from ⅛ to 3/16-in., and the reinforcing steel back is generally 16-gage, SAE 1010, cold-rolled steel. The function of the steel back is to hold the friction face together and to hold the rivet heads, while the thick central web serves as the rigid member and transmits torque to the splined hub.

Spline Teeth: Many friction disk units are designed with tangs or teeth. Tangs vary in length, depth and spacing, while teeth vary in pitch, pressure angle and shape. The loads applied to the teeth create shear stresses, since the teeth are the means of transmitting torque from the disk to the retaining drum. Bending stress is developed by the applied pressure and is made apparent in some applications by resistance to axial motion that occurs during pressure application. The teeth not only have to resist these static forces but also the dynamic forces which result from a suddenly applied load, and tend to peen the disk teeth when pressure is applied.

The average shear stress in a spline tooth of a disk exerting a torque of τ pound-inches is, *Fig.* 11:

$$s = \frac{\tau}{r_p n l t} \qquad (13)$$

where s = average shear stress, psi; n = number of spline teeth in disk; l = tooth length, in.; t = chordal tooth thickness, in.; and r_p = pitch radius of tooth, in.

Wet Clutch Design

Until recently, and over a long period of time, friction clutches have been predominantly dry friction mechanisms. There have been notable exceptions, such as a wet clutch in an automobile of a few years ago, but just previous to the advent of the automatic transmission, automobile clutches were almost universally dry. The drawback of this practice was that the clutch, once designed dry, must always be kept dry, even in the proximity of otherwise copiously lubricated bearings, gears and shafts.

The effect of contaminants on friction materials has been dealt with previously. Now that effective wet friction materials have been developed, the trend today is toward increased application of the wet clutch which does not have to be segregated from the lubricated parts of mechanisms, but may be bathed in the same medium.

The advantages offered by the wet friction clutches lie in (1) smoothness of engagement, (2) length of operating life, (3) ease of cooling and (4) simplification of sealing problems. However,

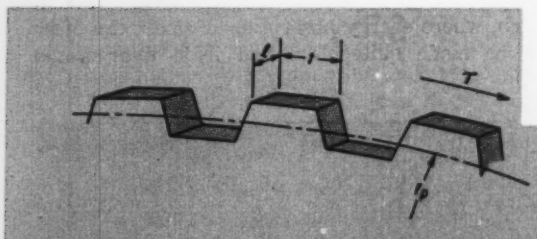
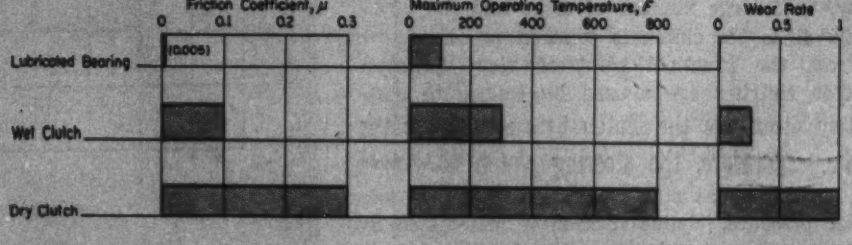


Fig. 11—Above—Typical construction of friction disk spline teeth with symbolic notation for analysis of shear stress

Fig. 12—Below—Comparison of operating characteristics for a lubricated bearing and wet and dry friction clutches. Comparative data are based on a condition of hydrodynamic lubrication for the bearing, boundary lubrication for the wet clutch, and no lubrication for the dry clutch



the sacrifice which must be made in designing for the oil or wet clutch in place of the dry clutch is reduced friction action. The level of wet friction is only about ⅓ that of dry friction, and it is therefore necessary to compensate by increasing the diameter or the number of disks.

Conditions of Wet Friction: Roughly speaking, wet friction applications fall somewhere between full hydrodynamic lubrication and absolutely dry friction, preserving some of the advantages, and disadvantages, of both. In hydrodynamic lubrication, a relatively thick oil film capable of supporting load is built up and maintained during operation. The film is so thick in comparison to the surface roughness of the journal and the bushing that there is no contact between asperities of the two surfaces. Therefore, friction and wear rate under normal operating conditions are low. Characteristics of friction level, maximum operating temperature and general wear rate for a lubricated bearing and wet and dry friction mechanisms are compared in *Fig.* 12. While this is a schematic treatment, specific values have been applied to friction and temperature levels.

As an example of typical surface characteristics, the level of dynamic friction of sintered-bronze facings in wet clutch applications will approach $\mu = 0.10$ as a maximum and may average about $\mu = 0.08$. Static friction in wet clutches will be in the range of $\mu = 0.11$ to 0.15. On the other hand, the normal level for dry friction is about $\mu = 0.30$. The wet clutch will, therefore, require two to three times as many disks as the dry clutch for the same load application. It is essential, having designed for wet operation, to maintain the oil film, or else the torque may become several times the design capacity and cause damage through high wear rate and harsh engagement.

Function of Grooves: The energy released as heat in wet clutch engagement is carried away by the oil. Good circulation of oil through the clutch plates is, therefore, essential. The clutch pack is normally a tight mechanism and even in disengagement there is little space between the disks for oil flow.

During engagement there is a tendency for the oil film to be scraped away. To maintain the protecting and lubricating effect of the oil film, oil must be supplied continuously to the surfaces of the friction faces. An effective way of furnishing the oil film is by pumping oil outward from the inner hub of the clutch. The friction faces may be machined with spiral and radial grooves to assist oil flow. The radial grooves allow the oil to move through them outward. Since, at the same time, there is circumferential motion of the disk, the oil is carried through the spiral grooves as well. Radial passages then carry the oil outside the clutch.

The spiral groove performs several useful functions: (1) It works to prevent the forming of an hydrodynamic oil film which would reduce friction, (2) it provides a place for the surface oil to be squeezed into during engagement, (3) it helps to circulate this oil, (4) it provides a place into which the products of wear, if any, may be swept and (5) it helps to maintain the desirable minimum oil film by continuously sweeping oil over the surface.

The functions of the radial groove are (1) to provide a channel for circulation of cooling oil through the clutch pack, (2) to collect and throw out loose particles, and (3) to help maintain the minimum oil film.

It is the function of radial slots to prevent coning and warping of friction disks. As a secondary function, slots do everything that radial grooves do.

In small wet clutch disks, no grooves or slots other than possibly spiral grooves may be necessary. But, in large clutch disks, spiral grooves, radial grooves and radial slots are good design. *Fig.* 13 is a rough summary of actual practice in a selected group of examples.

While this summary of practice is intended to be a guide only, it does show in graphic fashion that for wet friction disks of larger diameters it is likely that more machining will be done on them

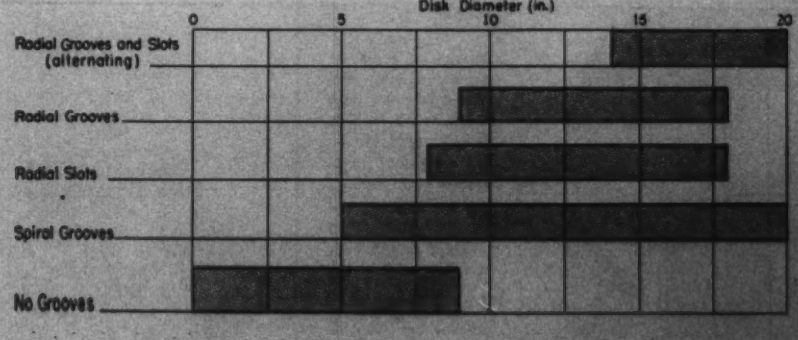


Fig. 13 — Suggested grooving practice for wet-clutch friction disks

to improve their performance. On the other hand, it may become desirable to do more machining than is here indicated on small sizes of disks when unusually high performance characteristics are expected. *Fig.* 14 shows some typical disk designs that exemplify the principles discussed.

Grooving Practice: The addition of spiral and radial grooving adds to the cost of manufacture of clutch disks. Evaluation of the cost of grooving requires knowledge of sizes, quantities and the type of grooving desired.

As to the dimensions of grooves, it is general practice to make the pitch of spiral grooves about 0.075 to 0.100-in., and the width of the groove about 0.020 to 0.030-in. Depth is usually less than the width, or about 0.015 to 0.020-in., reaching

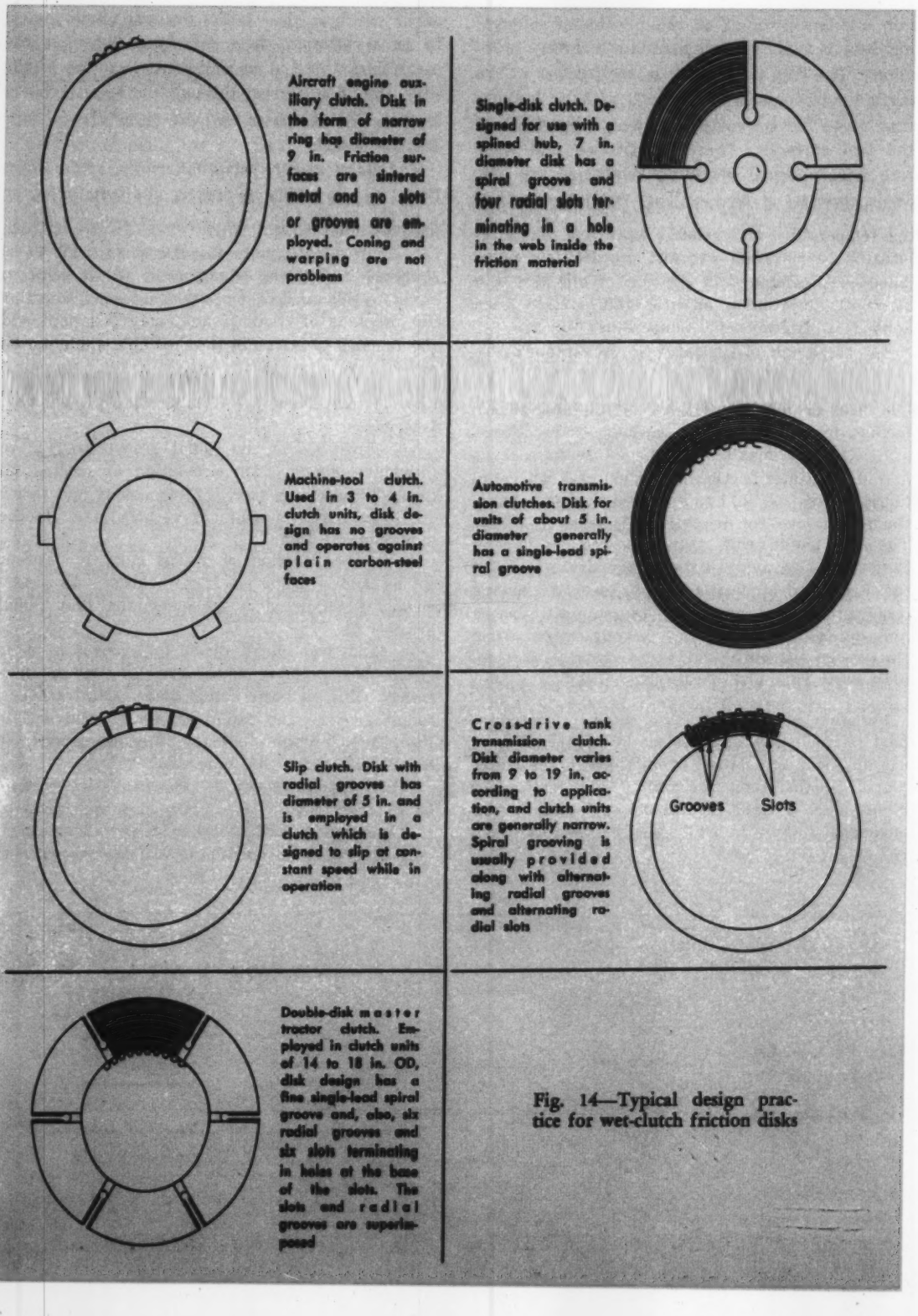

Aircraft engine auxiliary clutch. Disk in the form of narrow ring has diameter of 9 in. Friction surfaces are sintered metal and no slots or grooves are employed. Coning and warping are not problems
Single-disk clutch. Designed for use with a splined hub, 7 in. diameter disk has a spiral groove and four radial slots terminating in a hole in the web inside the friction material
Machine-tool clutch. Used in 3 to 4 in. clutch units, disk design has no grooves and operates against plain carbon-steel faces
Automotive transmission clutches. Disk for units of about 5 in. diameter generally has a single-lead spiral groove
Slip clutch. Disk with radial grooves has diameter of 5 in. and is employed in a clutch which is designed to slip at constant speed while in operation
Cross-drive tank transmission clutch. Disk diameter varies from 9 to 19 in. according to application, and clutch units are generally narrow. Spiral grooving is usually provided along with alternating radial grooves and alternating radial slots
Grooves
Slots
Double-disk master tractor clutch. Employed in clutch units of 14 to 18 in. OD, disk design has a fine single-lead spiral groove and, also, six radial grooves and six slots terminating in holes at the base of the slots. The slots and radial grooves are superimposed

Fig. 14—Typical design practice for wet-clutch friction disks

nearly, but not fully, to the depth of the friction face. While spiral grooves are usually single lead, in one case a 4-lead spiral was used to prevent concentric grooving of the face plate. This design was a severe application, and appreciable wear of both faces was anticipated. The shape of a typical groove section varies from rectangular with bottom fillets to semicircular. Walls may be vertical, or inclined to as much as 30 deg.

Radial grooves may vary in width from ⅛ to ⅜-in. In cross section they are rectangular with bottom fillets. They may be purely radial, put in one at a cut, or they may be put in by a double cutter, equidistant from and parallel to a radius. They may also be incomplete grooves alternately closed to the inside and outside diameter. In most applications the minimum spacing of radial grooves is 1 in.

Slots are generally slightly wider than the thickness of the unit, usually terminating in a drilled or punched hole which is either of the same diameter as the width of the slot or 50 to 100 per cent greater. In large clutch disks the slots may originate alternately on the inside and outside diameter. They usually continue about 2/3 the distance through the ring, except in the case of the through web, when slots terminate within the inside diameter of the facing.

Torque Characteristics: Some special uses of the wet clutch require a particular torque curve. One of these is a constantly slipping clutch which, while engaged, furnishes torque to another part of the mechanism. Speed hunting may result because the coefficient of friction tends to increase as speed decreases. The antidote for this condition is a flat curve of friction with speed—an ideal property.

As a rule, a clutch operating by a simple engagement and required to furnish unslipping static driving torque may take advantage of a material whose friction increases as speed decreases and whose static friction is greater than its dynamic friction. This property is typical of sintered-metal friction materials.

Steel Cores and Mating Plates: If the back or core is for a fairly large disk and requires teeth to be machined, the material is usually SAE 1035, hot-rolled steel. This steel can be obtained in sheets as thin as 0.091-in. and, possibly, as thin as 0.085-in. Where no teeth are required and the disk is large, SAE 1010 or 1020 cold-rolled can be used. In smaller disks, even though teeth are required, SAE 1020 may be used.

In most applications, wet friction materials are operated against steel disks. Spring steel, SAE 1065 to 1085, is often used and the steel is generally heat treated.

ACKNOWLEDGMENT

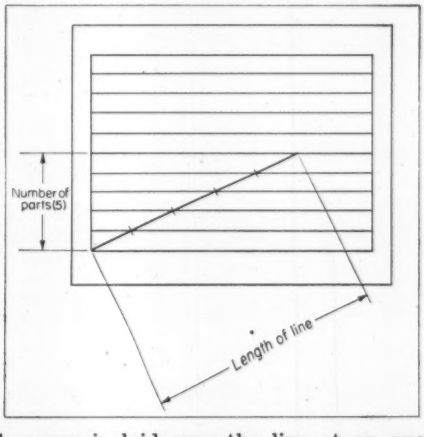
The author wishes to acknowledge with appreciation the co-operation of the following companies in supplying photos for this article:

New Departure Div., General Motors Corp. (*Fig.* 2) ..... Bristol, Conn.
Le Tourneau-Westinghouse Co. (*Fig.* 3) ..... Peoria, Ill.
Caterpillar Tractor Co. (*Fig.* 4) ..... Peoria, Ill.
Goodyear Aircraft Corp. (*Fig.* 5) ..... Akron

Tips and Techniques

Dividing Lines Into Parts

AN old but easy and accurate way of dividing any length line into any number of equal parts is to use transparent graph paper. The



graph paper is laid over the line at an angle so that the line exactly fits between the right number of divisions. Length of a division is then picked off with dividers, and the line on the drawing is divided. For best accuracy, angle between the graph-paper lines and the line to be divided should be large.—R. L. STEDFELD, MACHINE DESIGN.

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

"The truly great scientist, like the truly great person, is one who has great breadth of interest, who knows other disciplines, who sees the interrelationships of all branches of knowledge, who appreciates achievement in all areas of learning, and who is always sensitive to the best that has been thought and said whatever the field."—MARGARET HABIEN, *dean of instruction and student services, University of Rochester*

Protecting Design Ideas

Legal authority for protection of unpatented and uncopyrighted ideas against unauthorized use

By Albert Woodruff Gray, *Jackson Heights, L. I., New York*

AN INVENTOR of dial telephone equipment submitted his designs and drawings to a telephone company for consideration under the agreement that, should these inventions be used, the inventor would be given employment. The company returned the plans but, according to the inventor, copied them in detail and appropriated to use the inventions they described.

These drawings had neither been patented nor copyrighted. A New York Court in a recent decision in the action brought against the telephone company by this inventor for an injunction, said of the rights of the owner of the inventions, "The inventor did not patent his invention and a general statement has sometimes been made that an inventor's right to his unpatented work depends on his ability to guard successfully his secret and that the property right in the idea depends upon secrecy for its very existence.

"When the idea is published without patent or copyright or the product is produced, sold and open to examination anyone who has the ingenuity to utilize the idea or to dissect the product and discover the secrets may make free use of it without the necessity to account to its originator.

"But when the idea comes into the possession of one through confidential disclosure by the inventor or under contractual or other legal restrictions, its disclosure may be the breach of a trust which a court will restrain. If there is a profitable use made of it the nature of the knowledge acquired may result either in a requirement to account or damage for the invasion of the property right against one who has thus acquired the knowledge and misused the confidence."

Limits of Secrecy: A similar case recently before the United States Court of Appeals involved the pirating of the designs of a freight container equipped with high doors at one end and large enough for a man to enter. The container was adapted for use in standard-gage railroad cars and in the holds of vessels, and was removable by hoist while filled with cargo.

These plans, disclosed in confidence by the inventor, had been later acquired by a competitor. In its decision, the Federal Court said of the rights of an inventor under such circumstances, "We assume that almost any knowledge or information used in the conduct of one's business may be held by its possessor in secret. Of course, as the term demands, the knowledge cannot be placed in the public domain and still be retained as a secret. Thus an inventor would not be permited to copy the design of a known device and claim that the copies are his secret. That which has become

". . . when the idea comes into the possession of one through confidential disclosure by the inventor or under contractual or other legal restrictions, its disclosure may be the breach of a trust which a court will restrain."

public property cannot be recalled to privacy. However, this does not mean that the product must reach the stature of invention. All that is required is that the information or knowledge represents in some considerable degree the independent efforts of its claimant."

Mental Property: The courts in these decisions followed as authority the determination of an action before the Pennsylvania courts half a century ago. A steel car manufacturer sued for possession of blueprints it had supplied to railroads contemplating the purchase of steel cars to facilitate the ordering of repair parts or the repairing of the cars themselves. The plans had later been discovered in the possession of a competitor who opposed the effort of the owner of the drawings to regain possession on the ground that the blueprints had been acquired in the ordinary course of business.

Said the court, "This case recognizes the principle frequently asserted by the courts, that there is a property in a design, in the idea and in the mental conception as well as in the piece of paper on which it is expressed.

"A certain amount of publicity is inevitable in any manufacture but an unlocked door is not an invitation to the passerby or to the servant of the household to help himself. Neither does the manufacturer abandon his property in a design by delivering it or a copy to another for a restricted purpose nor by a limited publication.

"The property rights will be protected in such cases and he will be protected against a breach of trust, confidence or contract and especially will he be protected against a breach of confidence existing between employer and employee."

"A certain amount of publicity is inevitable in any manufacture but an unlocked door is not an invitation to the passerby or to the servant of the household to help himself. Neither does the manufacturer abandon his property in a design by delivering it or a copy to another for a restricted purpose nor by a limited publication."

Right to Protection: The court here compared the designs and plans for machines to the plans of architects and the right of the owner in both instances to protection: "A familiar example is that of architect's plans. Should a contractor be allowed to use in the construction of other buildings plans and specifications furnished him by an architect in connection with and as a necessary part of the builder's contract with the owner by whom the architect was employed. Or should he be permitted to turn them over to another achitect for his use.

"And if the owner asks for blueprints so that he may inspect his building during construction for his pleasure or information or for the purpose of making some alterations or conditions, would not his act in using them to obtain bids from other architects be considered by all right minded people a breach of decency and honorable dealing.

"Courts do not enforce abstract principles of ethics but this is something more. If the builders or the owners should be enjoined from using designs so obtained, equally so should the architect who unfairly and improperly receives the information in this manner.

"At common law," continued the court in this decision, "the author of a manuscript might obtain redress against one who has surreptitiously got possession of it. An inventor does not lose his rights unless he suffers his invention to go into public use without objection. The exclusive right to one to make reproductions of a picture does not justify another to make and sell photographs. So the exhibition of a blueprint of machinery in the office of the purchaser, although done by permission of the manufacturer, a copy of whose drawing it is, certainly is not a general publication and an abandonment of exclusive rights in the drawing."

Legal Principles: Another incident, typical of these situations in which the property right is in designs and drawings, or better, in the idea which such designs and drawings express, occurred when patterns for a rotary pump were taken by the inventor to a pattern maker for repair and surreptitiously copied. In his defense to the action brought to prevent the marketing of pumps from these patterns, the infringer contended that since the pumps manufactured by the owner of these patents had been freely marketed and were in public domain he was at liberty to copy the patterns.

The pump had been patented and the patents had expired. Improvements had been made but the patterns for the improvements had been kept secret and never disclosed to the public. The

"An inventor does not lose his rights unless he suffers his invention to go into public use without objection."

court in prohibiting the use of these patterns by the infringer, said, "Suppose, for instance, that the successful operation of the machine required it to be constructed of a composition or combination of metals which was the device and invention of the manufacturer, could it be said that the sale of the machine, to be devoted to the uses for which it was constructed, carried with it the right to the secret formula by which the inventor had combined the material out of which it was constructed or the manner in which the material had been treated and prepared for use. We think not. Take a more common illustration, one with which the courts are familiar, having been the subject of frequent adjudications, that is, the compounding of medicines for specific diseases where the inventor maintains the secret of the compounding as a part of his trade or business.

"The courts have uniformly restrained all persons in his employ who necessarily become possessed of the formula in the manufacture of the article from subsequently engaging in its manufacture or from imparting it to others, thus in effect holding that the sale of the compounded article to the world was not a publication of the formula or device used in its manufacture.

"It consequently appears to us that the manufacture and sale of the pumps in question was not a publication of the plans, specifications and patterns from which the pump was manufactured. That so far as the improved pump was concerned the inventor had the right to keep the plans, specifications and patterns from the public and thus secure to himself the benefit of the business in which he was engaged; that the infringer had no right to procure copies surreptitiously without the knowledge of the inventor by employing one of his pattern makers or repairers to so make them."

The infringer appealed from this decision and, over fifty years ago, the highest court of New York established this principle of law that protects designs and machine drawings, in this case, machine patterns, from the piracy of those who would ride on another's running board.

"Every new and innocent product of mental labor which has been embodied in writing or some other material form, being the exclusive property of its author, the law secures it to him as such, and restrains every other person from infringing his right."

"The fact that one secret can be discovered more easily than another does not affect the principle. Even if resort to the patterns of the inventor was more of a convenience than a necessity, still if there was a secret it belonged to him and this infringer had no right to obtain it by unfair means or to use if after it was thus obtained.

"We think that the patterns were a secret device that was not disclosed by the publication of the pump. While the infringer could lawfully copy the pump because it had been published to the world, he could not lawfully copy the patterns because they had not been published but were still in every sense the property of the inventor who owned not only the material substance but also the discovery which they embodied."

In an earlier decision, this same court summarized the law which thus protects machine designs and patterns, as it does every other original and unpublished effort of this character, "Copyright before publication is the exclusive privilege of first publishing any original material product of intellectual labor. Its basis is property. A violation of it is an invasion of property and it depends entirely on the common law.

". . . the exhibition of a blueprint of machinery in the office of the purchaser, although done by permission . . . certainly is not a general publication and an abandonment of exclusive rights in the drawing."

"Every new and innocent product of mental labor which has been embodied in writing or some other material form, being the exclusive property of its author, the law secures it to him as such, and restrains every other person from infringing his right.

"Whether the ideas thus unpublished take the shape of written manuscripts or literary, dramatic or musical compositions or whether they are designed for works of ornament or utility, planned by the mind of an artist, they are equally inviolable while they remain unpublished and the author possesses an absolute right to publish them or not as he sees fit and if he does not desire to publish them, to hinder their publication either in whole or in part by anyone else."

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Designing with Nylon

Practical recommendations for engineering design of nylon parts

Part 2—Dimensional Control; Design of Gears and Bearings

By A. J. Cheney
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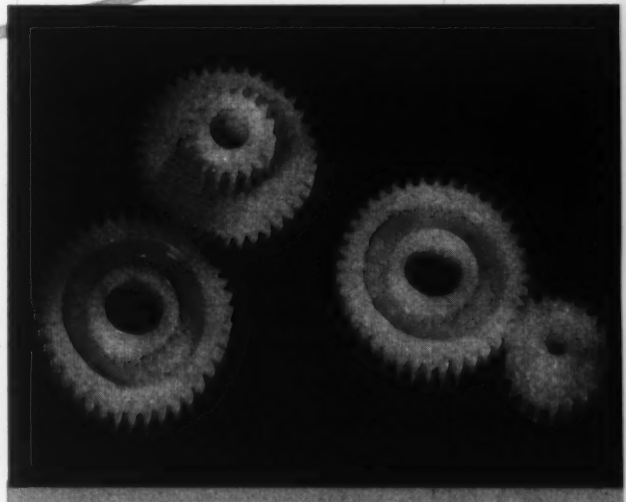
E. I. du Pont de Nemours & Co. Inc.
Wilmington, Del.



Injection-molded nylon gears can be made with integral shoulders, in integral molded pairs or clusters, or with thinner sections. Advantages include good bearing characteristics (operation without lubricant is possible), rapidity of finished-part production, and lightness of weight

DESIGN of nylon parts does not have to be a cut-and-try affair. Moisture content, temperature, and cold-flow characteristics have to be carefully considered, but fundamental design principles still apply. Part 1 of this series has discussed these factors, plus design by use of strength and deformation criteria. The present article will cover dimensional control, production specifications, and design of gears and bearings.

Dimensional Control: Dimensions of parts made of nylon are determined by the temperature and moisture content of the material. The thermal coefficient of expansion of Zytel 101 is 5.5×10^{-5} in. per in. per deg F.

As already mentioned in Part 1, nylon will slowly absorb moisture from its surroundings until an equilibrium condition is reached. This results in a growth in all dimensions until, at equilibrium, a stable condition is reached. Then little further change due to variation in moisture content will occur even though the surroundings change considerably.

Moisture is absorbed on the surface and then diffuses into the center of the material. The diffusion rate is very slow; thus, thickness has a considerable effect on the time required to reach equilibrium and upon the change in dimensions with environmental changes.

Amount of moisture absorbed by Zytel 101 at equilibrium with air at 50 per cent relative humidity is 2.5 per cent, and in water is approximately 8.5 per cent. Rates of moisture gain for several thicknesses are shown in *Fig.* 6.

Size increase from the dry as-molded condition to a moisture content of 2.5 per cent is 0.008-in. per in., *Fig.* 7. In water, the maximum growth is 0.028-in. per in.

The changes described are large, but they represent a change that should seldom or never occur. If a part is conditioned to a water content approx-

imately half-way between the expected extremes of the exposure, the subsequent change in dimensions with variations in moisture content will be small. For instance, if a molded part is conditioned to 2.5 per cent water, each dimension will grow 0.008-in. per in. This change should be allowed for in the design of the mold. The expected variation in air will then be in the order of ±0.001-in. per in. with normal changes in relative humidity after moisture conditioning.

Production Specifications: Two things should be specified in the production of parts where dimensional stability is important: (1) annealing, and (2) moisture conditioning. In some cases, these two steps can be combined into one operation.

Fig. 6—Moisture gain versus time for several thicknesses of nylon (Zytel 101)

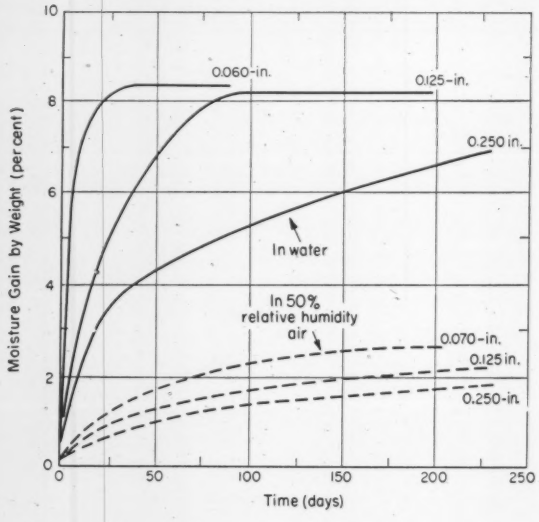
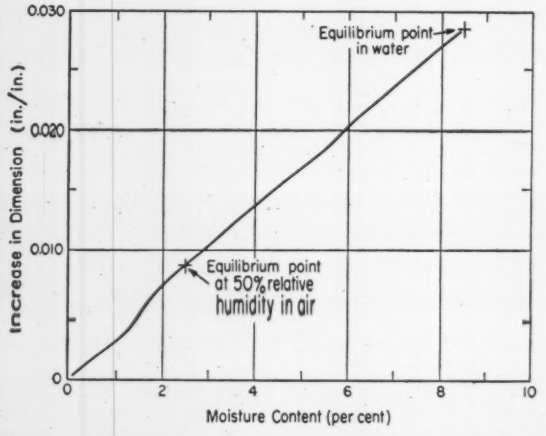


Fig. 7—Increase in dimensions of nylon parts as moisture content increases from dry, as-molded condition



As-molded parts will have some internal stresses molded in, depending upon the operating conditions used. These can be relieved by an annealing treatment. Parts should be annealed at 300 F for 15 minutes per ⅛-in. of thickness using a high-boiling point material such as Glyco Wax S-932 or an oil.

Moisture conditioning can be done in several ways. The most practical for average air service is to boil in water until approximately 3 per cent has been absorbed by weight. These parts should then stand in air for about 2 weeks before use so that the excess moisture in the skin is removed. While this does not guarantee absolutely uniform moisture distribution through the part, the dimensional changes that will occur later will be small.

For service in water, boiling to or near saturation will take care of the major change. Approximate boiling times for various thicknesses are shown in *Fig.* 8.

For parts exposed only to temperatures below 160 F, the boiling water treatment is also sufficient to anneal the parts.

Design of Gears: One of the major applications for nylon is in gears. Not only can finished gears be molded economically in a simple operation, but they are quiet and have very low wear rates even though little or no lubricant is used.

Experience necessary to design gears has not generally been available, so that many of the present applications have resulted from experimentation or simply direct substitution for metal gears.

Any design method used with other materials should be adaptable to use with nylon if the properties, as described in Part 1, are selected correctly. For instance, the Lewis equation can be used, although it usually gives highly conservative results. The reason, undoubtedly, is that this equation is based on all the load being applied to a single tooth whereas with nylon two or more teeth are normally used.

Hall[1] reports that four test gears were run for 50 million cycles at a calculated maximum tooth stress by the Lewis formula of 7870 psi using the tooth form-factor for the load on the tip of

[1]References are tabulated at end of article.

Table 8—Form Factors: Lewis Gear Equation

Number of Teeth	Gear-Tooth Form . . . 14½°	20° Full Depth	20° Stub
	Form Factor (load at middle of tooth) . . .		
12	0.113	0.132	0.158
14	0.127	0.149	0.172
16	0.137	0.160	0.184
18	0.146	0.166	0.192
20	0.153	0.173	0.200
24	0.162	0.182	0.211
30	0.172	0.193	0.222
50	0.187	0.221	0.241
Rack	0.210	0.262	0.280

the tooth. This apparent stress is above the material's fatigue strength. Using the form factor for loads near the middle of the tooth[2], the stress was calculated to be 4600 psi. Examination of the gears showed that two teeth always take the load. Therefore, according to Buckingham, one tooth will receive only 60 per cent of the load. This reduces the calculated stress value to 2760 psi, which more closely checks the fatigue endurance data shown in *Table* 2 (Part 1). Under the conditions described here, these gears were transmitting 3.7 hp.

Gears of Zytel 101 can be designed using the Lewis equation:

$$W = Spfy$$

where W = tooth load, lb; S = working stress, psi; p = circular pitch, in. = (π × pitch diam)/(No. of teeth); f = face width, in.; and y = tooth-form factor. Values for y given by Buckingham are shown in *Table* 8.

Safe working stress values can be taken from either the tensile strength or from fatigue endurance data. For applications in air at or slightly above room temperature, one-third of the tensile strength or of the fatigue endurance limit, whichever is smaller, is used for design. For gear work, these fatigue data are conservative, since they are for reversed stresses where the gear tooth is only stressed in one direction.

Velocity of the gears also must be taken into account. The velocity factor for nonmetallic gears is usually taken as

$$F = \frac{150}{200 + v} + 0.25$$

where F = velocity factor; and v = pitch-line velocity, fpm. Applying this velocity factor to the fatigue data gives very conservative values for the safe working stress.

If, from the geometry of the gears, it is apparent that at least two teeth will always take the load, the force transmitted can be taken as 1 2/3 times the calculated value with safety.

Suppose, for example, that a maximum load of 1 hp is to be transmitted at 1750 rpm by a 20-pitch gear with a 2½ in. pitch diameter (50 teeth) and 20-degree pressure-angle full-depth teeth.

For this application, the tensile strength is approximately 9000 psi, so one - third of this value would be 3000 psi. Pitch-line velocity v = (π × 2.5/12) 1750 = 1145 fpm. Width can be found from the Lewis formula

$$f = \frac{W}{Spy}$$

where

$$W = \frac{1(33{,}000)}{1145} = 29 \text{ lb}$$

$$S = 3000\,F = 3000\left(\frac{150}{200 + 1145} + 0.25\right) = 1080 \text{ psi}$$

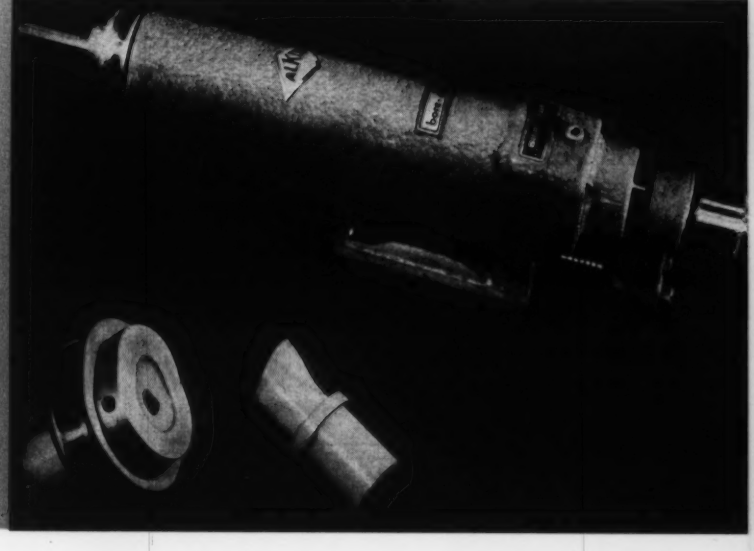
$$p = \frac{\pi\,(2.5)}{50} = 0.157\text{-in.}$$

and y, from *Table* 8, equals 0.221. Then face width of the tooth

$$f = \frac{29}{1080\,(0.157)\,(0.221)} = 0.77 = \tfrac{3}{4}\text{-in.}$$

If this gear operates with a 10-tooth pinion so that only one tooth is in contact, then a ¾-in. wide gear should be used. On the other hand, if running with a larger gear so that at least two teeth are always in contact, then a 15/32-in. wide

Splined bushing in an air-powered drill unit must have low coefficient of friction so spindle can slide in and out easily. A polygon-ground triangular connection provides ample bearing surface for power transmission, but permits easy sliding. Reduction of shock and vibration by use of the nylon bushing is said by the manufacturer, Alkon Products Corp., to reduce drill breakage, increase life and eliminate chatter during operation



gear (60 per cent) would be ample.

The question whether mold shrinkage affects the tooth profile is often raised. Actually, the pitch diameter of the mold has to be made larger to compensate for radial shrinkage of the entire gear. Effects on the tooth profile, however, appear to be so small that they can be ignored.

The only shrinkage values affecting the profile will be those within the tooth itself. From a theoretical calculation, this should change the angle of the involute section of the tooth by no more than ¼-degree. An attempt to check this by examination of a 20-fold magnification of a mold cavity and the 16-pitch gear molded from this cavity resulted in the conclusion that there was no measurable change in pressure angle.

Most of the gears now made of nylon resin, even when running with metal gears, perform satisfactorily without lubricant. Undoubtedly some lubricant would reduce the rate of wear, but apparently this is already so low that it is not the limiting condition. Gears artificially loaded to failure exhibit either a typical beam failure because of the tooth breaking at the root or the tooth deforming out of shape.

Design of Bearings: A rapid and fairly accurate method for screening bearing applications is to use the *pv* factor—the product of load in psi of projected bearing area and the surface velocity of the shaft in fpm. Certainly for unlubricated or initially lubricated bearings that are expected ultimately to run without lubrication, the *pv* values are the best data available for design use. These values are of less importance in the design of lubricated bearings.

Typical commercial and test results reported as *pv* values are given in *Table* 9. It should be remembered that many factors affect bearing performance, so that these values should be used as a guide only.

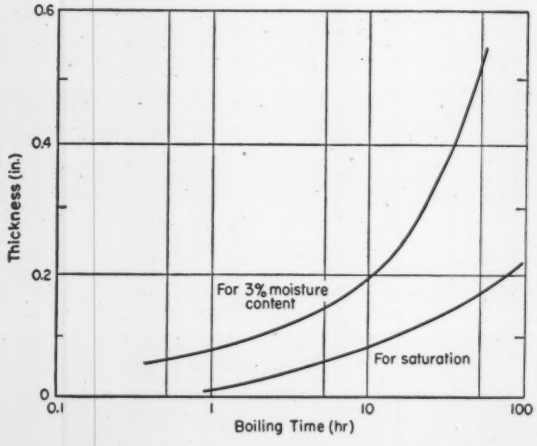
Nylon resins can be used as a dry bearing where many materials would not be successful. This is particularly true if an initial shot of lubrication is applied. Any good lubricating oil or grease can be used.

Water has no corrosive effect on nylon and acts somewhat as a lubricant. The bearing should be sized when saturated so that the original clearance will be maintained in service.

The important effect of oil on the bearing performance of nylon is not always realized. A 1-inch diameter by 1-inch long bearing on a steel shaft was lubricated with SAE 20 oil at the rate of three drops per hour. The shaft had a surface finish of 15 micro-inches, rms. With a clearance of 0.005-in., the bearing limits were 1000 psi at 600 rpm, 730 psi at 1000 rpm and 600 psi at 2000 rpm. Hydrodynamic lubrication was maintained, and the coefficient of friction varied between 0.008 and 0.010, for loads *above* 250 psi. At lower loads, the friction coefficient *increased*.

Of even more interest, after the bearing ran for about 6 hr with oil, the source of lubrication could be removed for as long as 3 days, and the

Fig. 8—Boiling times to moisture-condition Zytel 101 nylon. Approximately 3 per cent water content is suggested for air service; saturation for service in water



Nylon gear for a loom runs without lubrication to avoid product spoilage by a lubricant. The gear is machined from nylon bar stock.

bearing still maintained hydrodynamic lubrication. It appears that nylon deforms under bearing pressure but does not change at the edges, thus effectively sealing the oil in the bearing.

A number of investigators have reported coefficient of friction data. While these differ considerably, as Milz and Sargent[3] point out, test equipment and conditions so greatly affect the results that no comparison can be made. A summary of their data and representative data from other sources are given in *Table* 10.

Work at Du Pont to date on factors affecting the coefficient of friction indicates that metal particles from the shaft, dirt, or wear particles have the most effect. More data are being obtained on bearings so that methods for more accurately predicting bearing performance can be developed.

Summary: "Engineering" nylons, such as Zytel 101, have been found to be highly useful in industry. For example, nylon gears are operating without lubrication in textile looms, thus greatly reducing the yield loss caused by product contamination. Bearings of nylon are operating quietly in automobile brake-pedal cross-shafts where lubrication would be difficult to maintain. Coil forms are used in radios because they are tough enough to eliminate the problem of breakage during winding, yet can be made with thin wall sections so they are highly efficient. Door-lock wedges of nylon are used on car doors because they can withstand impact, yet do not screech or gall even though unlubricated. Nylon gears are used in household appliances to reduce the noise level and because no lubrication is required.

In design, mode of failure can be predicted and working stress levels adequately calculated. Effect of environment on properties can be taken into account, and designing for cold flow or creep is not difficult. Wear and possible chemical attack present design problems not as easily solved but, as more data are obtained, these can also be put on a firm design basis.

In short, basic principles of machine design today apply to nylon just as they do to any other material of construction.

Table 9—PV Values for Nylon Bearings

Lubrication Condition	Type of Operation . . . Continuous	Intermittent	Sporadic[1]
	PV Values[2] (psi × fpm) . . .		
Dry	500	1000	10,000
Oil, initially lubricated	2000	2500	>10,000
Water	2500	2500	No data
Oil, wick lubrication	50,000	70,000	.....

[1]Examples are door hinge bushings and drawer or door rollers.
[2]For Zytel 101 nylon resin.

Table 10—Nylon Coefficient of Friction Data

Other Surface	Lubricant	Load (psi)	Coefficient of Friction
Battelle Memorial Institute; Neely or boundary film testing machine; surface speed, 156 fpm			
Nylon	None	1050	0.04 to 0.13
	Water	1050	0.08 to 0.14
	Oil	1050	0.07 to 0.08
Steel	Water	1050	0.3 to 0.5
	Oil	1550	0.02 to 0.11
Brass	Water	1050	0.3 to 0.5
	Oil	1550	0.08 to 0.14
Milz and Sargent[1]; crossed-cylinder apparatus with various surface speeds from 8 to 367 fpm.			
Tool steel	None	1 to 5	0.15 min; 0.33 max
	Water	1 to 5 (367 fpm)	0.14 min; 0.18 max
	Oil	1 to 5	0.09 min; 0.14 max
Du Pont; sleeve bearing tests; hydrodynamic lubrication; 1-in. diam shaft at 1000 rpm.			
	SAE 20 oil	20	0.04
		50	0.023
		100	0.013
		200	0.011
		300	0.010
		500	0.009
		650	0.008
		730	0.009

[1]Reference 3.

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industrial design Ideas

who's your boss?

AS a designer, who's your boss? Simple question—simple answer: "the person who buys your products."

How, then, can you satisfy his demands for fair price, high quality, good looks, convenience, etc? Again a simple answer: "get off your stool and go out to find out." This is a lot different than an occasional tour through your own plant to find out how your brain-children look in metal, yet this is as far as many designers go.

In my years in design, I have jammed my notebook with ideas gleaned from talking to production men operators, and customers—ideas that were put into final designs. You can do the same, regardless of your products or your markets. If you have a market research department, so much the better, but be sure to use their findings before drawing a single line.

How often I have run into manufacturers who decide they must build a 9⅞-inch hoot-nanny because all their competitors build a 9⅞-inch hoot-nanny—only to find, too late, that a majority of their customers require 10-inch hoot-nannies.

Moral: Use your legs before using your pencil.

—Cliff

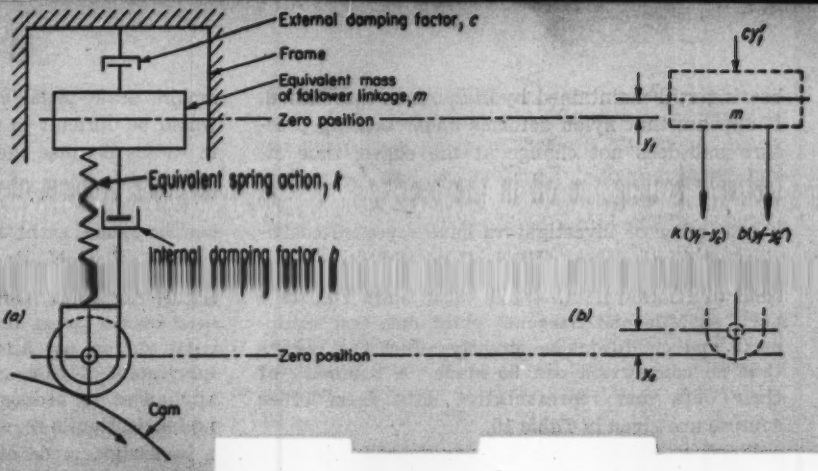

Fig. 1—Representative cam-follower mechanism showing, *a*, corresponding equivalent-mass system and, *b*, graphical analysis of forces acting on the follower linkage

Cam Dynamics

of high-speed systems

Acceleration Characteristics
Vibration Effects
Surge Phenomenon
Impact Loads
Balancing Considerations
Production Limitations

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Nomenclature

a = Acceleration, in. per sec^2
b, c = Damping constants for follower linkage (*Fig.* 1), lb-sec per in.
F = Force, lb
f_a = Number of free vibration cycles of the follower linkage for the positive acceleration period
h = Total rise of follower, in.
K_d = Dynamic magnification factor (*Fig.* 5)
k = Equivalent spring constant of the follower linkage, lb per in.
m = Equivalent mass of the follower linkage, lb-sec^2 per in.
$n = \omega_f/\omega$ = Frequency ratio
t = Elapsed time, sec
y = Displacement, in.
β = Angular displacement of cam for total follower rise h, radians
β_a = Angular displacement of cam for positive acceleration period of follower, radians
θ = Angular displacement of cam, radians
ω = Angular velocity of cam, radians per sec
$\omega_f = (k/m)^{1/2}$ = Natural vibration frequency of follower linkage, radians/sec
y' = First derivative of displacement (velocity), in. per sec
y'' = Second derivative of displacement (acceleration), in. per sec^2

AS OPERATING speeds increase, dynamic characteristics of cam and follower systems become more difficult to predict and control in design. Vibration and deflection of elastic system elements, as well as other unfavorable phenomena, introduced under high-speed action only add more variables to already complex force and motion relationships. In addition, the higher the speed, the more critical the accuracy of cam fabrication and surface finish if anticipated results are to be realized in practice. What these factors mean in terms of design criteria will vary with the individual case, and will have to be evaluated on the basis of performance objectives and production facilities.

In this article, the various dynamic aspects of high-speed cam-follower systems will be discussed. Factors influencing cam and follower operation are analyzed, and recommendations are presented for effective solution of design problems.

Sources of Vibration: All cam-follower systems are subject to some form of vibration. At low operating speeds, vibration characteristics of a system are rarely a matter of concern, but at high speeds they usually become significant. The various sources of vibration in cam operation are summarized in the following discussion.

1. ACCELERATION. Not only are the effects of acceleration and corresponding forces important, but also the rate of application of these forces can be a significant factor in high-speed systems. A useful concept that offers a practical index of dynamic system characteristics is the rate of change of acceleration or, as it will be called here, "pulse." The term "jerk" has also been applied to this concept by other authors. As will be shown later, a condition of infinite pulse ($da/dt = \infty$) is undesirable.

2. SEPARATION OF CAM AND FOLLOWER. Impact of re-engagement of cam and follower surfaces after contact is broken can produce severe vibratory deflections.

3. SURFACE IRREGULARITIES. Quality, accuracy,

This article is based upon information appearing in a forthcoming book, *Cams—Design, Dynamics and Accuracy*, to be published by John Wiley and Sons Inc., New York.

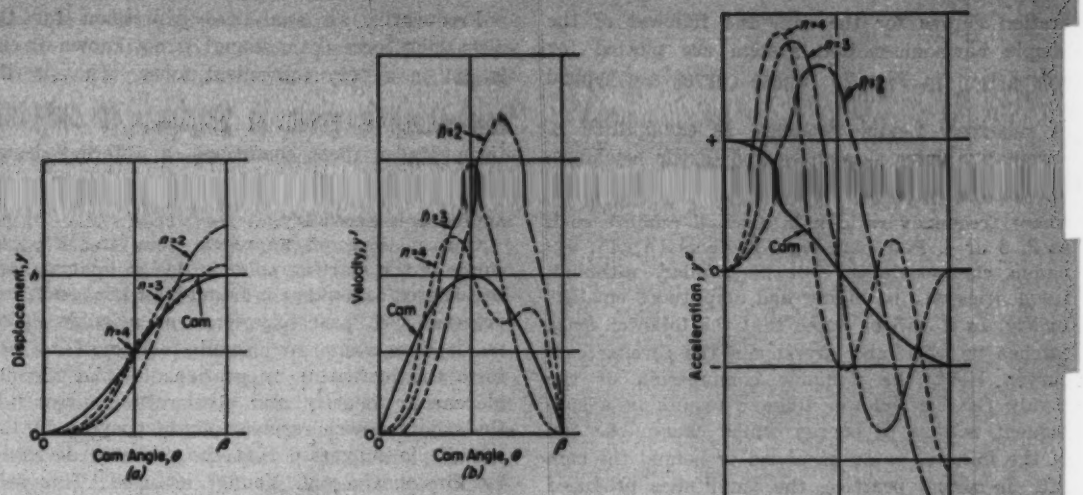

Fig. 2—Characteristic curves of simple-harmonic motion cam-follower systems with varying frequency ratios. Curves are: *a*, displacement; *b*, velocity; and *c*, acceleration. Solid lines represent cam action, broken lines follower response

and general working condition of the contact surfaces become more critical factors in cam performance as operating speeds increase.

4. EXTERNAL LOADS. Rate of application of loads during the machine work cycle may introduce secondary forces into the cam-follower system.

5. MISCELLANEOUS SOURCES. Cam unbalance is always a possible source of vibration but can be partially combatted in design through control of the distribution of mass in the cam structure and body. Among other possible sources, which are many, vibration may be transmitted to the cam-follower system from the machine drive elements or from external sources.

In the following sections, the various sources of vibration and other significant factors in high-speed cam operation will be analyzed.

Follower Motion: As an aid to analysis of cam dynamics, it might be best to examine first the actual motion of a follower in a representative system, *Fig.* 1. For convenience, the concept of equivalent mass, m, will be applied to the follower linkage. The follower is at rest when $t = 0$.

The basic force relationship is

$$\Sigma F = my'' \quad \ldots\ldots (1)$$

For the general type of system under consideration, *Fig.* 1, this expression becomes

$$-b(y_f' - y_c') - cy_f' - k(y_f - y_c) = my'' \quad \ldots\ldots (2)$$

where subscripts c and f designate cam and follower elements, respectively.

For different cam profiles, an expression for the motion characteristics of the follower may be determined by substituting in Equation 2 the analytical expression for cam displacement y_c. A simple harmonic cam design with a dwell-rise-dwell movement will serve as an example of the method of solution. For simplicity, damping will be considered to be negligible. Displacement of the simple harmonic cam form is given by

$$y_c = \frac{h}{2}\left(1 - \cos\frac{\pi\theta}{\beta}\right) \quad \ldots\ldots (3)$$

where $0<\theta<\beta$. Substituting this expression in Equation 2 and solving yields the general equations for displacement, velocity and acceleration, or response, of follower mass m:

$$y_f = \frac{h}{2}\left[\frac{1}{\left(\frac{n\beta}{\pi}\right)^2 - 1}\right] \times \left(\cos n\theta - \cos\frac{\pi\theta}{\beta}\right) \quad \ldots\ldots (4)$$

$$y_f' = \frac{h}{2}\left[\frac{1}{\left(\frac{n\beta}{\pi}\right)^2 - 1}\right] \times \left(\frac{\pi\omega}{\beta}\sin\frac{\pi\theta}{\beta} - \omega_f \sin n\theta\right) \quad \ldots\ldots (5)$$

$$y_f'' = \frac{h}{2}\left[\frac{1}{\left(\frac{n\beta}{\pi}\right)^2 - 1}\right] \times \left[\left(\frac{\pi\omega}{\beta}\right)^2 \cos\frac{\pi\theta}{\beta} - \omega_f^2 \cos n\theta\right] \quad \ldots\ldots (6)$$

Characteristic displacement, velocity and accel-

eration curves for the cam and follower of the simple harmonic-motion system are plotted for comparison in *Fig.* 2.[1] These curves are typical of relatively flexible systems, as exemplified in automotive valve assemblies and textile machines, where frequency ratio n is a small number such as 2, 3 or 4. For more rigid systems ($n>4$), dynamic characteristics will be similar, although frequencies will be higher and amplitudes smaller. In *Fig.* 2*a* it will be noted that the follower mass catches up with and overshoots the forcing cam curve. Here, the dynamic compression of the highly flexible follower linkage results in a subsequent release of energy which causes the end of the follower to surge ahead or behind the cam lift. In actual practice, the amplitudes produced by this action will be reduced by damping.

Thus, the natural frequency of the follower linkage should ideally be kept as high as possible. Then, if resonance occurs, it will be at a higher frequency ratio where vibratory amplitudes are lower. Also, the more rigid the system, the closer the response of the follower mass conforms to the cam contour.

In the same manner as for the foregoing simple-harmonic cam example, the approach outlined may also be utilized to find the follower response characteristics for other cam forms and systems.

[1]References are tabulated at end of article.

Frequently, an analytical expression for the disturbing force (cam shape) is not known or else is not in a very convenient form. That is, the cam shape is given in graphical or numerical form. Under these conditions, a different design approach is necessary.

One method of approach uses the $d^4y_c/d\theta^4$ curve as the starting point in design analysis, and the desired cam shape is found by a trial and error process, with past experience as a guide. Electronic computers are usually employed to perform the increment integrations to find the displacement, velocity and acceleration curves. To find the follower response characteristics in this case, it is suggested that the equation developed by Timoshenko and Young[2] be used. This relationship is based on the fact that a disturbing force proportional to the acceleration can be considered as a succession of constant forces: m (a_1, a_2, a_3, . . .). Generally speaking, a smooth "bumpless" acceleration curve will yield the smallest follower vibration response.

Objections to the application of "theoretical" follower motion and accurately determined acceleration curves in high-speed cam design are generally based on the fact that with ordinary manufacturing accuracy the actual follower motion already deviates appreciably from that calculated. This condition is particularly true of acceleration characteristics and vibratory exciting forces.

Some attention has been directed toward development of lift curves and cam contours with greater emphasis on practical manufacturing requirements. Schlaefke,[3] on the basis of calculations showing the influence of machining accuracy, suggested a follower motion in which the accelera-

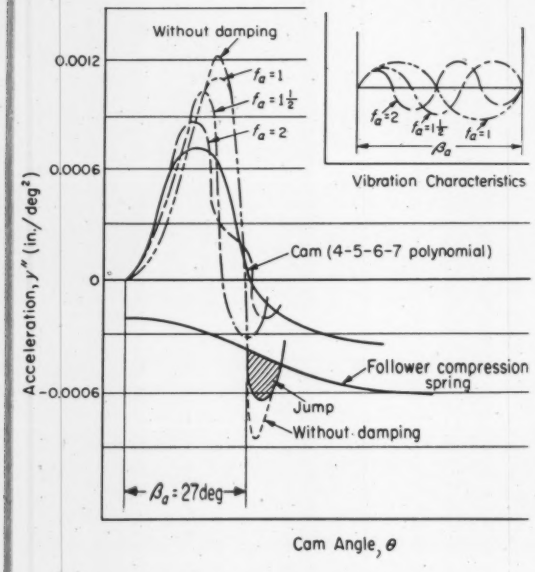

Fig. 3—Graphical analysis of jump phenomenon in high-speed cam-follower systems. Solid line represents acceleration of unsymmetrical cam form; broken lines show corresponding follower response characteristics with damping. Jump occurs when negative acceleration of follower dips below the follower compression spring curve. Cam is rotating at speed of 2100 rpm

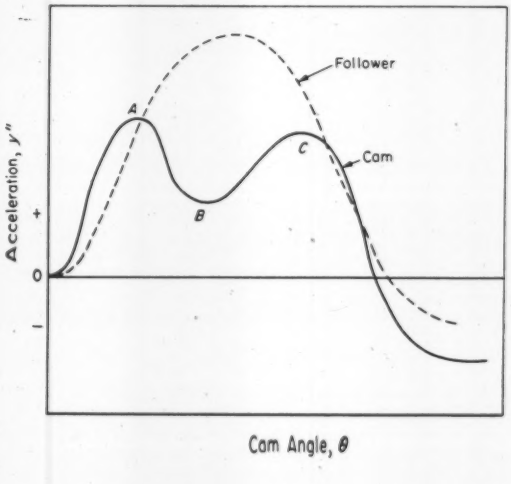

Fig. 4—High-speed polydyne cam-follower system in which the cam acceleration curve has been tailored to eliminate the possibility of jump

tion curve is of parabolic shape (not to be confused with the traditional "parabolic" or constant-acceleration curve). In a more recent development, Johnson[4] has proposed an arithmetical method of cam design which can be readily adapted to conventional cam manufacturing techniques and yields results well within practical accuracy limits.

Although damping was neglected in the previous simple-harmonic cam example, refined investigations necessitate its inclusion in system analysis. It is known that the damping ratio in most cam-follower assemblies is generally 10 to 25 per cent of the critical value. Vibratory amplitudes can often be reduced by increasing the damping action; however, this method should be used with discretion since the damping forces may become greater than the dynamic operating forces. Although complex in design and analysis, damping devices offer promising possibilities in the improvement of operating characteristics of high-speed cam-follower systems.[13]

Cross-Over Shock: Vibratory response of the follower mass in a high-speed cam-follower system may be subject to a phenomenon called "cross-over shock." This condition is common to all positive, but not preloaded, drive cams where the contact position of the roller follower shifts from one side of the cam track to the other when the acceleration changes direction. Thus, clearance, or backlash, between the follower and cam elements is taken up by the resulting impact.

Intensity of cross-over shock is proportional to the maximum velocity of the follower linkage; both decrease as the follower is made stiffer, *Fig.* 2 *b*. Thus, for minimum cross-over shock, the follower linkage should have a high natural vibration frequency.

Also, it can be shown by mathematical analysis that certain cam contours, such as the cycloidal form, which have finite, rather than infinite, pulse at the dwell and transition points give the best results. Cross-over shock is minimized because of the small vibratory amplitudes inherent with these types of profiles. The parabolic or constant acceleration form, on the other hand, is poor.

When cross-over shock occurs, additional vibrations are introduced into the cam-follower system, adding to those already present. A practical solution to this condition is offered by dual roller followers that are preloaded against the cam contour to prevent the occurrence of backlash and cross-over shock.

Jump Phenomenon: Compression spring-loaded followers are subject to a disturbance, similar to that of cross-over shock, which might best be called jump or bounce. This disturbance is the result of a transient condition that occurs only with high-speed, highly flexible cam-follower systems.[5]

With jump, the cam and the follower are separated by unbalanced forces that exceed the follower compression spring force during the period of negative acceleration. As a result, the fundamental functions of the cam-follower system, constraint and control of follower motion, are not maintained. Short life of the cam flank surface, high noise, vibration and poor follow action are related consequences.

From the previous analysis of follower motion, it is apparent that the shape of the acceleration response curve is related to the number of full cycles of natural follower vibration completed during the acceleration time interval at the particular operating speed. The number of natural or free vibration cycles for the positive acceleration range is given by

$$f_a = \frac{\beta_a}{2\pi} \sqrt{\ldots}$$

The acceleration curve of a typical high-speed unsymmetrical cam is shown in *Fig.* 3. Plots of the corresponding follower acceleration response characteristics for different values of f_a appear as superimposed curves. These latter curves include the effects of damping which can be determined by the methods discussed previously (Equation 2). In addition, a curve representing the follower compression spring characteristics has been included in *Fig.* 3 for comparison. This curve must fall below the negative acceleration values if constraint of the follower on the cam is to be maintained. Jump occurs when the follower response curve dips below the spring curve. It can be seen that jump is more likely to occur with smaller values of f_a and n.

Proper choice of cam acceleration curve shape, having finite pulse values, can keep jump to a minimum. It is further apparent from analysis of high-speed acceleration curves that vibratory jump does not occur if $f_a > 2$. Increasing spring load is not a desirable method for eliminating jump since increased surface stress and shorter life result.

The polydyne method[6] of cam design offers a practical approach for eliminating jump in highly flexible cam-follower systems. In this method, the acceleration response curve and motion characteristics of the follower are first established, and the cam shape is determined accordingly. Follower and cam acceleration curves of a polydyne system designed to meet such requirements are shown in *Fig.* 4. The negative cam acceleration "dip" (*ABC*) opposes the jump condition. This dip, however, is sometimes difficult to fabricate.

Comparison of Cam Forms: Analysis of some of the fundamental cam curves will be helpful in establishing a proper basis for high-speed cam design. A subject of recent investigation [7,8] was the effect of vibration in three basic dwell-rise-

dwell systems with follower linkages of high rigidity.

Vibratory response characteristics, with damping, of the three systems investigated—parabolic, simple harmonic and cycloidal — are shown in *Fig.* 5. The ordinate used in these plots is the dynamic magnification factor, K_d, which represents the ratio of the actual force, deflection or stress to the corresponding inertial force, deflection or stress.

In *Fig.* 5, the simple harmonic and parabolic curves, with their infinite pulse characteristic, show large vibrations, $K_d = 2$. The cycloidal curve, on the other hand, has small values of magnification, $K_d = 1.06$. All vibrations occur at the natural frequency of the follower linkage.

Thus, infinite pulse represents a sudden, or transient, application of inertia load. The result is a shock load of about twice the magnitude of the normal dynamic load in the cam-follower system. As the frequency of this impressed force approaches a value that is a small odd integer multiple of the natural frequency of the system, it is known that vibration becomes more serious because of resonance. The resonant condition is likely to be of less consequence in cycloidal than other basic cam forms. However, the fabrication tolerances for the cycloidal profile are critical. Accuracies of ± 0.0003 inch may be required for satisfactory performance.

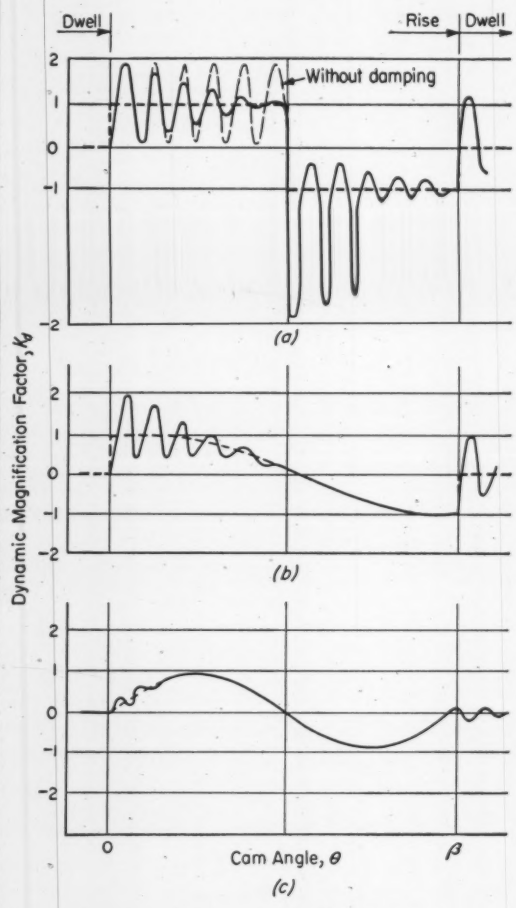

Fig. 5—Vibratory follower response characteristics, with damping of three basic cam systems: *a*, parabolic; *b* simple harmonic; and *c*, cycloidal. Broken lines represent theoretical acceleration values

Pulse Characteristics: The question is sometimes asked, "What pulse value should be used for minimum vibratory effects?" It has been shown[9] that the trapezoidal, the modified trapezoidal and the cycloidal acceleration curves, *Fig.* 6, are particularly suited to high-speed operation. Vibration characteristics of the three systems are closely similar, although the maximum acceleration values of the modified trapezoidal are smaller than those of the cycloidal form.

Based on the analytical techniques discussed previously, it could be theoretically verified that further reduction in pulse at the dwell ends of the motion cycle does not reduce vibration. That is, "side sloping" of the acceleration curve does not act to reduce vibratory amplitudes. Moreover, blending of the acceleration curve with the dwell ends to provide zero pulse boundary conditions does not necessarily improve cam action.

For systems with finite pulse values, an important consideration is the effect of cyclic or repetitive dynamic forces. Vibrations remaining in the system after the work cycle are theoretically of significance with respect to the vibratory amplitudes in successive cycles; the next application of cam contour forces during the following stroke may increase the stresses and deflections in the mechanism. In general, a high natural frequency,

Although further mathematical analysis of cyclic force action is possible, it is usually not justified for several reasons:

1. All irregularities on the contact surfaces will have an influence on cam operation since there is generally a large difference between the theoretical and actual cam acceleration curves. This deviation has a significant effect on follower acceleration and motion characteristics.

2. Inherent damping in the cam-follower system will decrease the amplitude of residual vibrations. This damping effect is, of course, improved as the natural frequency of the system is increased.

3. Two significant factors in cyclic force generation, cam speed and natural frequency of the follower linkage, may vary during operation. In the first case, the forced vibrations which are a function of cam speed will vary slightly according to the type of prime mover. For example, operation of electrical equipment is affected by voltage variations. In the second case, the natural frequency of a machine is not exact and is affected by radial clearance in bearings, frictional resistance of metals in contact and lubricated surfaces, changes in loads handled by the machine, dynamic oil film effects, bowing of column members, and the flexibility and mass of a system.

Calculations for natural frequency can be as much as 20 per cent in error. A more accurate

method[10] employs electrical oscillographic equipment directly on the actual machine or model. The natural frequency for automobile overhead valve linkages may range from 40,000 to 50,000 cycles per minute and for aircraft valve systems, from 20,000 and 30,000 cycles per minute.

All of the foregoing factors decrease the possibility of resonance from cyclic forces. This effect is especially true in properly designed high-speed continuous cam contours.

Surface Irregularities: Cam and follower surface imperfections are sometimes difficult to control or analyze. These surface irregularities induce vibrations that may be more severe than all the other types discussed.

As pointed out previously, the condition of cam and roller surfaces has a definite influence on the vibrations induced in the follower. This fact has been substantiated by the author with strain-gage oscillographs of follower action. A surface may be dimensionally acceptable but dynamically poor, and vice versa. In the automotive field, surface finishes of 4 microinches maximum for sliding followers and 50 microinches for cams are sometimes used.

In the case of cycloidal profiles, for example, contour accuracy must be closely controlled. A few thousandths inch error in initial and final stages of the cam rise path will definitely affect follower performance.

Surface irregularities produce high-frequency, low-amplitude vibrations. The only practical, although costly, solution to this problem is more accurate fabrication and inspection of cam and follower contact surfaces.

Three kinds of cam and follower surface imperfections[11], *Fig.* 7, are possible: (1) roughness, (2) waviness and (3) errors. In operation, each of these three surface irregularities may be a separate source of vibration with additive effect on each other or with other vibrations in the system.

ROUGHNESS, *Fig. 7a,* is a random distribution of many small high and low points in the surface. Because of the random distribution, any change in the surface is just as likely to decrease the existing vibration as to increase it. The net effect is a low-level vibration (usually negligible), which is usually absorbed by damping due to residual oil in these micropockets.

WAVINESS, *Fig. 7b,* on the other hand, is a periodic surface imperfection and is identified by a uniform distribution of high and low points of larger duration than roughness. It may be produced by excessive cutter feed in the continuous generation of a cam profile with a milling cutter. Also, in the generation of cam shapes by peripheral cutting of increment locations, scallops are formed that may not be eliminated. Because wavi-

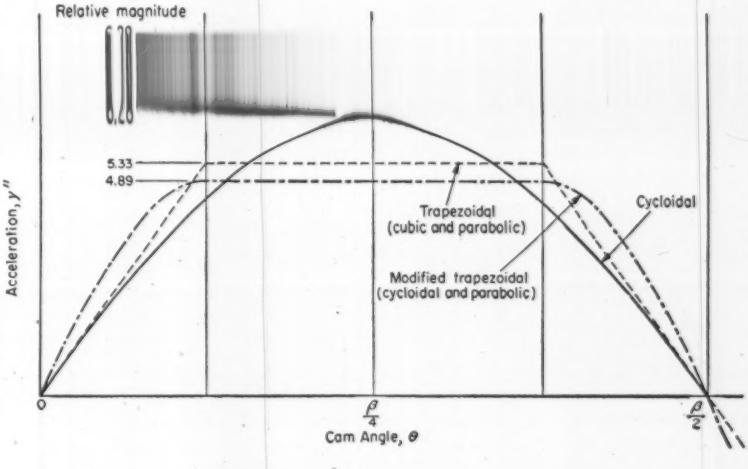

Fig. 6—Comparison of acceleration characteristics for three "symmetrical" high-speed cam forms

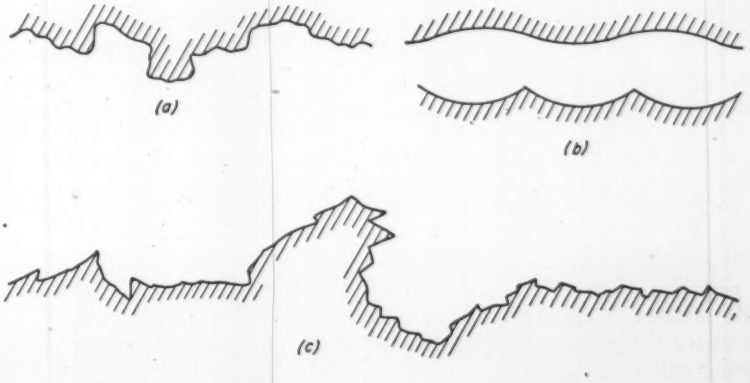

Fig. 7—Three basic types of cam and follower surface imperfections: *a,* roughness; b, waviness; and *c,* errors

ness is periodic, the effects of successive imperfections will sometimes tend to reinforce each other at certain operating speeds.

ERRORS, *Fig. 7c*, are local in character and can be any size, shape or duration. They can be produced by an incorrect setting of the increment milling cutter, a file scratch, or by holding the grinding wheel too long at a point on the cam. Such errors can create serious vibrations in any system. For example, the author has found that an error, 0.003-in. high and 0.010-in. long, on a cam surface can produce vibratory forces exceeding the spring force in a highly flexible system.

In practice, many cams are found to have characteristics that differ from their theoretical counterparts because of fabrication limitations with certain machining methods. For example, continuous cutting-grinding equipment may resist a sudden change in the acceleration characteristics of the master cam and, as a result, produce a cam with better operating characteristics. In such cases, the actual cam is generally an improvement over the master. At the same time, however, if the grinder starts to chatter because of shock excitation from a discontinuous acceleration characteristic, a serious waviness condition may be produced in the surface. These results simply underline the possibility that cam fabrication may under certain conditions be subject to many of the same dynamic principles that govern cam operation.

A cam surface may appear or feel smooth and yet still have serious surface imperfections from the standpoint of vibration. Therefore, if vibration is a problem, it may be best to first analyze actual surface accuracies before conclusions are drawn as to the effect of the existing cam curve or profile.

Balancing: One of the problems in high-speed cam action is unbalance, or eccentric location of the cam mass from the center of rotation. Strong vibrations may be induced in the cam-follower system. This vibration, although it cannot be completely eliminated, can be kept to a minimum by proper cam proportions, using a well-ribbed low-mass design. It perhaps should be pointed out that cylindrical and radial-face cams offer the best dynamic balance characteristics and are, therefore, sometimes adapted to high-speed operation.

Follower Spring Surge: The basic function of a follower compression spring is to maintain cam and follower contact. At high speeds, however, a phenomenon occurs that may substantially reduce the effective force of the spring, permitting separation of the cam and follower surfaces, even though considerable surplus spring force is provided. This condition is called spring surge, and is characterized by a torsional vibration wave that is transmitted through the spring wire, up and down the coils, at the natural frequency of the spring.

Spring surge has been found to be the result of a state of resonance with cam high-amplitude harmonics. In general, the lower the harmonic number, the higher the vibratory amplitudes. Harmonic number, in this case, is defined as the ratio of spring natural frequency to cam speed.

Spring surge can be readily prevented. The natural frequency of the spring should be high enough so that vibratory amplitudes are kept to a minimum. The harmonic number should be 11 or higher, although a ratio as low as nine may be used with a smooth cam acceleration curve. Additional information on the subject is available in the literature.[5,12]

Design Guide: Theoretical and practical considerations in the design of high-speed cam-follower systems are summarized, for convenience, in the following section.

1. The cam acceleration curve should be smooth with maximum cam acceleration values as small as possible. That is, the maximum time and the minimum throw or movement of the follower should be used as a basis for design.

2. Pulse (da/dt) should never equal infinity because of the high stresses, severe resonant vibrations and cyclic vibratory effects that result. Thus, the cam acceleration curve should be a continuous function, and practical pulse values should approach those of the cycloidal system at the dwell ends of the cam movement.

3. The cyclodal cam form,

$$y_c = \frac{h}{\pi}\left(\frac{\pi\theta}{\beta} - \frac{1}{2}\sin\frac{2\pi\theta}{\beta}\right)$$

will, in general, fulfill the requirements of most dwell-rise-dwell machine motions if the cam can be made to the necessary accuracy. The trapezoidal and modified-trapezoidal cam acceleration curves, having lower maximum acceleration values, may in some cases, offer advantages. All are excellent choices from the standpoint of low follower vibration.

4. For highly flexible cam-follower linkages, the possibility of "jump" is eliminated when $f_a > 2$.

5. System elements should be made as rigid as possible to keep natural frequency high. Materials such as laminated thermosetting resins, carbides and other new high stiffness materials offer promising possibilities.

6. Component moving parts of the machine should be kept as light as possible. Materials such as magnesium, aluminum, titanium are desirable where their application is feasible.

7. Surface finish and accuracy of fabrication are of prime importance. Cams should be machined to match theoretical contours accurately so that the results of mathematical analysis are not lost. Surface errors should be kept to a minimum. As a result of unavoidable surface imperfections, actual dynamic characteristics rarely agree exactly with theory.

8. Backlash in system elements should be held to a minimum. Preloaded bearings and followers are possible solutions.

9. Overhang of follower translating elements should be kept to a minimum, and follower bearing guide length to a maximum. This practice will

permit the use of larger pressure angles, give smoother cam action, and produce a smaller cam.[14]

10. Low-friction bearings should be used wherever possible and all mating surfaces should be lubricated.

11. The possibility of cam unbalance should be minimized in design through proper proportioning and distribution of mass.

Despite careful application of the foregoing principles, operational difficulties may still hamper the performance of machine elements. In such cases, it is possible that the design of the cam and follower linkage is faulty. In fact, the conditions of operation may be such that requirements cannot be fulfilled by a mechanical system. Other physical systems employing electrical, hydraulic or pneumatic elements may be necessary and should be investigated.

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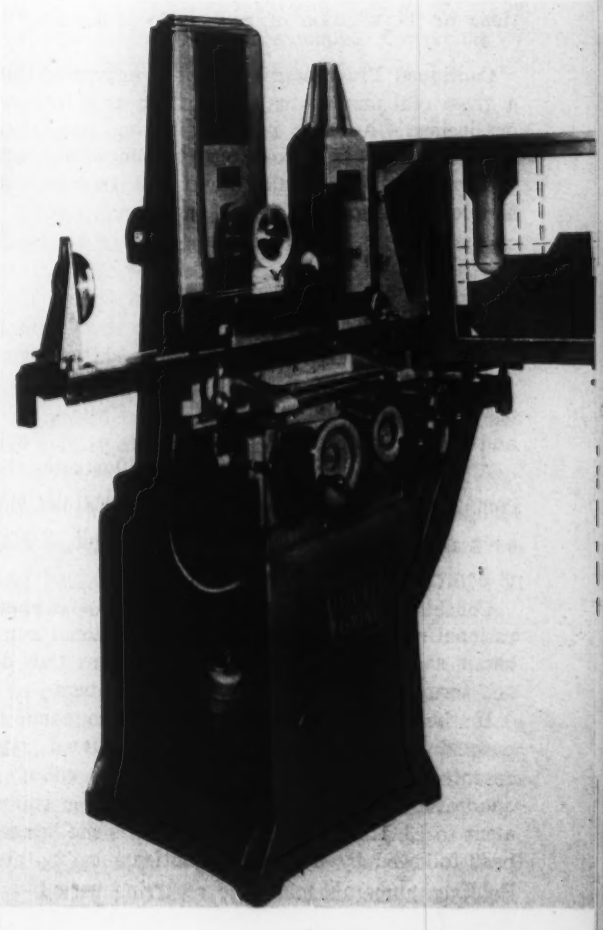
Contemporary Design

Grinder Incorporates Comparator

PRECISION grinding is made more precise by the incorporation of an optical comparator with a large screen into a precision grinding machine. Made by Cleveland Grinding Machine Co., the Visual-Grind machine has the comparator screen placed so that it is directly to the right of the operator as he faces the machine controls. Continual observation of the work as it progresses is thus possible.



How the Rational Plane complements other methods for finding GEAR RATIOS

By Arne Benson
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TWO MATHEMATICAL tools, continued fractions and conjugate fractions, are often employed to solve gear train problems. Both methods may be interpreted in terms of the "rational plane." Basic properties and a few examples of the use of this new concept were presented in the February 23 issue of MACHINE DESIGN. Further examination of the rational plane will show its relation to continued fractions and conjugate fractions in the solution of gear ratio problems.

Continued Fractions: A number approximating a given real number may be written as a fraction or decimal. Another notation having properties adapting it to the problem of finding these approximations is called a continued fraction. A simple continued fraction is of the form

$$a_1 + \cfrac{1}{a_2 + \cfrac{1}{a_3 + \cfrac{1}{a_4 + \ .}}}$$

and may be written as $N = [a_1, a_2, a_3, a_4, \ldots, a_n]$.

A sample problem, *Fig.* 1*a* and *b*, illustrates the computation necessary to express a typical decimal as a continued fraction. In this example, 2.0617 is equivalent to [2, 16, 4, 1, 1, 3, . . .].

Continued fractions that terminate express rational numbers. Conversely, every rational number is so expressible. Continued fractions that do not terminate represent irrational numbers.

If the set of partial quotients from some a_i onward recurs periodically, the irrational represented by the continued fraction is called a quadratic irrational. For example, $\sqrt{13}$ is equivalent to [3, 1, 1, 1, 1, 6, 1]. Here, a_1 is the integer part followed by its partial quotients a_2, a_3, etc. Boldface numerals mark the recurring period.

When a continued fraction neither terminates nor recurs, it represents an algebraic irrational of higher order than 2 or a transcendental irrational number. Thus, the continued fraction for π is [3, 7, 15, 1, 292, 1, 1, . . .].

Given a continued fraction N, successive convergents may be computed as shown in *Fig.* 1*c*. Let p be the numerator and q the denominator of the convergent, then $p_1/q_1 = a_1/1$, $p_2/q_2 = [a_1, a_2]$, $p_3/q_3 = [a_1, a_2, a_3]$, . . ., $p_n/q_n = [a_1, a_2, a_3, \ldots, a_n] = N$. Each p/q is a fraction of the lowest terms; each fraction alternating greater and less than the number N and always approaching N.

Any convergent p_n/q_n may be calculated with

$$p_n = a_n p_{n-1} + p_{n-2}$$

$$q_n = a_n q_{n-1} + q_{n-2}$$

A great deal of computation is eliminated using these relations as illustrated in *Fig.* 1*d*.

For any two adjacent convergents, p_i/q_i and p_{i+1}/q_{i+1},

$$p_i q_{i+1} - p_{i+1} q_i = \pm 1$$

This property, demonstrated in *Fig.* 1*e*, makes continued fractions valuable for the theory of rational approximations. If two fractions in lowest terms, a/b and c/d, are such that $ad - bc = \pm 1$, then every fraction between them will have a denominator $b + d$ or larger.

The "best approximation" is the nearest fraction to a number $R = n/d$ that can be found having a lower denominator. Then the best approximation would be the next to the last convergent computed from the continued fraction expansion of R. This approximation will be greater or less than the desired number R, depending upon whether the convergent is odd or even, *Fig.* 1*c*.

The relation between a continued fraction and

Fig. 1—Sample calculations showing how an expression for a continued fraction is developed

(*a*) **Numerical example**

$$2.0617 = 2 + \cfrac{1}{16 + \cfrac{1}{4 + \cfrac{1}{1 + \cfrac{1}{1 + \cfrac{1}{3 + \ldots}}}}}$$

(*b*) **Method for computing partial quotients**

$$a_1 = 2$$

$$a_2 = \frac{1}{0.0617} = 16\,\frac{128}{617}$$

$$a_3 = \frac{617}{128} = 4\,\frac{105}{128}$$

$$a_4 = \frac{128}{105} = 1\,\frac{23}{105}$$

(*c*) **Successive convergents computed from numerical example**

$$\frac{p_1}{q_1} = \frac{2}{1}$$

$$= 2 \qquad \text{(less than } N\text{)}$$

$$\frac{p_2}{q_2} = 2 + \frac{1}{16}$$

$$= \frac{33}{16} = 2.0625 \qquad \text{(greater than } N\text{)}$$

$$\frac{p_3}{q_3} = 2 + \cfrac{1}{16 + \cfrac{1}{4}}$$

$$= \frac{134}{65} = 2.0615 \qquad \text{(less than } N\text{)}$$

$$\frac{p_4}{q_4} = 2 + \cfrac{1}{16 + \cfrac{1}{4 + 1}}$$

$$= \frac{167}{81} = 2.06172\ldots \qquad \text{(greater than } N\text{)}$$

(*d*) **Equation method for finding a convergent**

$$\frac{p_n}{q_n} = \frac{a_n\,p_{n-1} + p_{n-2}}{a_n\,q_{n-1} + q_{n-2}}$$

$$\frac{p_3}{q_3} = \frac{(4)\,(33) + 2}{(4)\,(16) + 1} = \frac{134}{65} = [a_1, a_2, a_3]$$

(*e*) **Check of adjacent convergents**

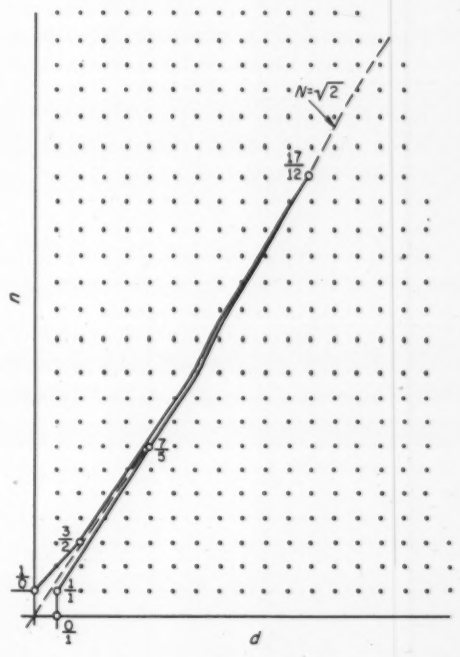
$$p_1\,q_{i+1} + 1 - p_{i+1}\,q_i = \pm 1$$

$$p_2\,q_3 - p_3\,q_2 = (33)\,(65) - (134)\,(16)$$

$$= 2145 - 2144$$

$$= 1$$

Fig. 2—Graphical representation of a continued fraction in the rational plane



the rational plane can be demonstrated by assuming that a graphical representation of the rational plane, *Fig.* 2, is a board with small pins sticking perpendicularly out of the plane. Assume $N = \sqrt{2}$ for the purpose of this example. Converting N into a continued fraction,

$$N = \sqrt{2} = 1.41421\ldots = [1, 2]$$

Successive convergents to N are 0/1, 1/0, 1/1, 3/2, 7/5, 17/12, 49/29, 99/70, . . .

If the line N is assumed to be a string extending from the origin to infinity, it will touch none of the pins, since $\sqrt{2}$ is irrational.

If the string is removed from the origin and pulled taut against 1/0, it will touch the pins representing the even-number convergents. These are 1/0, 3/2, 17/12, 99/70, . . .

If pulled taut against 0/1, the string will touch the odd number convergents, 0/1, 1/1, 7/5, . . .

Accompanying examples illustrate practical applications of the relationship between fractions and the rational plane. Five examples demonstrating basic uses of the rational plane appeared in the February 23 issue (page 106).

Conjugate Fractions: Another method of solving gear train problems involves use of an ascending series of irreducible fractions each equal to or less than 1. The numerator and denominator of each of these fractions is equal to or less than a particular number k. This is called a Farey series of the order k.

For example, a Farey series of the order 6

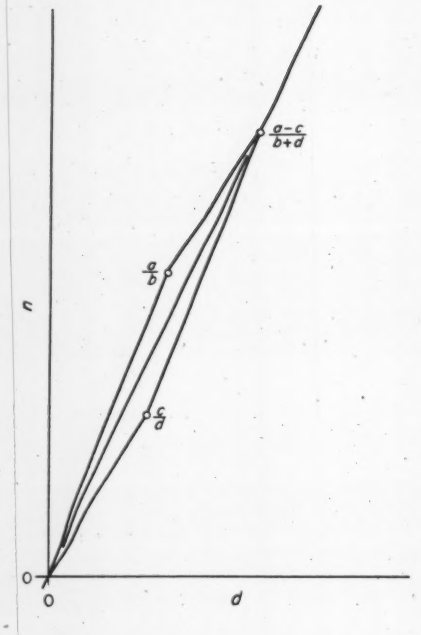


Fig. 3—Parallelogram formed in the rational plane by two conjugate fractions and their mediate. No point is contained in the interior of the parallelogram

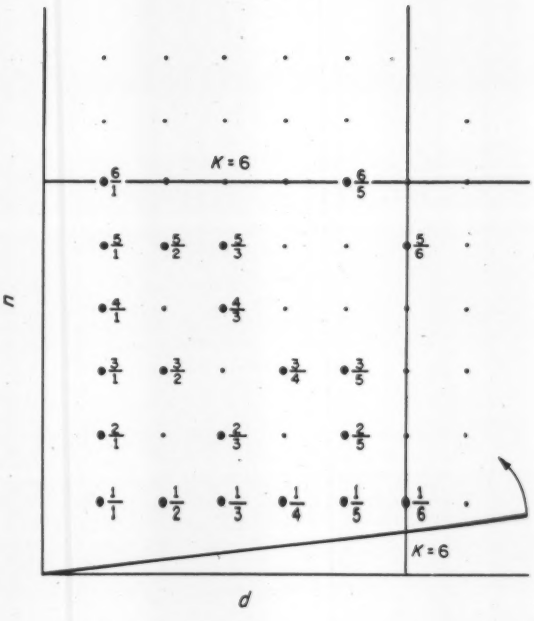


Fig. 4—How a series of conjugate fractions may be picked from a representation of the rational plane. Numerators and denominators do not exceed 6. As the vector rotates it touches each point in order of increasing magnitude

would be 0/1, 1/6, 1/5, 1/4, 1/3, 2/5, 1/2, 3/5, 2/3, 3/4, 4/5, 5/6, 1/1. These fractions have properties similar to the properties of convergents to a continued fraction. That is, if a/b and c/d are adjacent, then $ad - bc = \pm 1$. Consequently, each is the best approximation to the other by a fraction not having a greater denominator. Two such fractions are called conjugate.

For example, assume that the fractions 18/17 and 17/16 have been selected, by another method, as an approximation to 53/50. To test the approximations without expanding the fractions in decimal form the principle of conjugate fractions may be applied.

Let $a/b = 53/50$; $c_1/d_1 = 18/17$; $c_2/d_2 = 17/16$. Then $ad_1 - bc_1 = 901 - 900 = 1$ and $ad_2 - bc_2 = -2$. Consequently 18/17 is the best approximation to 53/50 with a denominator less than 50 + 17 or 67. In other words, 18/17 is conjugate to 53/50.

To find a fraction intermediate in value and conjugate to a/b and c/d, the numerators and denominators of both are added. Thus, the resulting fraction is $(a + c)/(b + d)$. This process is called mediation. In fact, every fraction between a/b and c/d is of the form $(ax + cy)/(bx + dy)$. Obviously no fraction exists between a/b and c/d with a denominator less than $b + d$.

Mediation can be portrayed graphically, *Fig.* 3. A parallelogram is formed by the origin, the two conjugate fractions a/b and c/d, and their mediate $(a + c)/(b + d)$. No point is contained in the interior of the parallelogram.

With 0/1 and 1/1 as terminal values, a Farey series, F_k, may be formed by successive mediation. Any fraction whose numerator or denominator exceeds k is discarded. The resulting series of fractions is sometimes referred to as a Brocot table.

A series of fractions whose adjacent fractions are conjugate may be formed if any one of the following properties exist:

1. Numerators and denominators of the fractions in the series lie between 0 and k. This property is interpreted in *Fig.* 4. The Farey Series F_k and its reciprocals is swept out in order of increasing magnitude by the radius vector as it rotates from $n = 0$ to $d = 0$. This series is (0/1, 1/6, 1/5, . . ., 6/1, 1/0).
2. Numerators of the fractions in the series lie between 0 and k; denominators lie between 0 and t.
3. Sum of the numerator and denominator $(n + d)$ of each fraction n/d lies between 0 and k.

Summary: The problem of finding the best approximation to a given rational number $R = n/d$ reduces to solving the equation $nx - dy = \pm 1$. Either the method of continued fractions or the Farey-Brocot series may be used.

Approximations to a given irrational number are best found by using continued fractions. Both methods complement the graphical method available with the rational plane.

Certain problems occur for which no systematic methods of solution exist. These are problems involving the selection of a set of gears for a set of given ratios subject to multiple conditions on the gears.

It may be required, for example, that all the drivers of the gear pairs be the same, or that the center distance $(n + d)$ be constant, or that the set of gears be minimum in number. Such problems are usually solved by trial and error. No strictly determinate solutions are known in the rational plane, but the very fact that the conditions of the problem can be depicted graphically affords considerable aid.

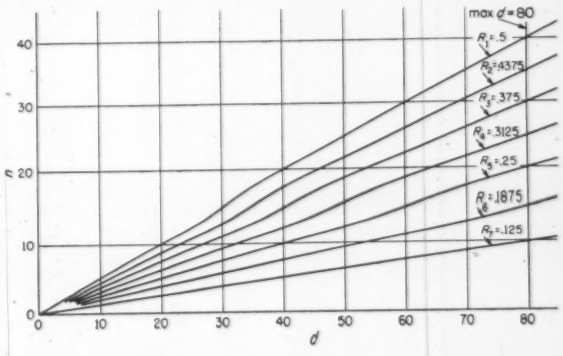
Applications of the Rational Plane

Example 1

Problem: **Select a set of gears to produce seven ratios: $R_1 = 0.5$, $R_2 = 0.4375$, $R_3 = 0.375$, $R_4 = 0.3125$, $R_5 = 0.25$, $R_6 = 0.1875$, $R_7 = 0.125$. The same pinion must be used for each ratio, since in the design the pinion is cut into the end of the driver shaft. The driven gears, d_i, are mounted on an adjustable stud whose range of movement limits the sum of the teeth in a pair to a maximum of 80.**

Find n and d_i $(i = 1, 2, \ldots, 7)$ such that $R_1 = n/d_1$, $R_2 = n/d_2, \ldots, R_7 = n/d_7$. Fractions corresponding to the R's are 1/2, 7/16, 3/8, 5/16, 1/4, 3/16, 1/8. Clearly, no exact solutions are possible wherein the numerators are less than 105, their least common multiple. Therefore, approximations must be found.

Solution: **Draw the lines representing the R's and max $d = 80$. It is apparent that n can not exceed 10, for any larger numerator will not intersect all the R's to the left of $d = 80$ as required. Assume the pinion cannot have less than 7 teeth. Scanning along $n = 7, 8, 9, 10$, the closest approximations are found along $n = 10$. The ratios are:**



$R_1 = 10/20$ (exact)

$R_2 \doteq 10/23 = 0.43478\ldots$ (error $= -0.00272$)

$R_3 \doteq 10/27 = 0.0370\ldots$ (error $= -0.004630$)

$R_4 = 10/32$ (exact)

$R_5 = 10/40$ (exact)

$R_6 \doteq 10/53 = 0.188679\ldots$

(error $= +0.001170\ldots$)

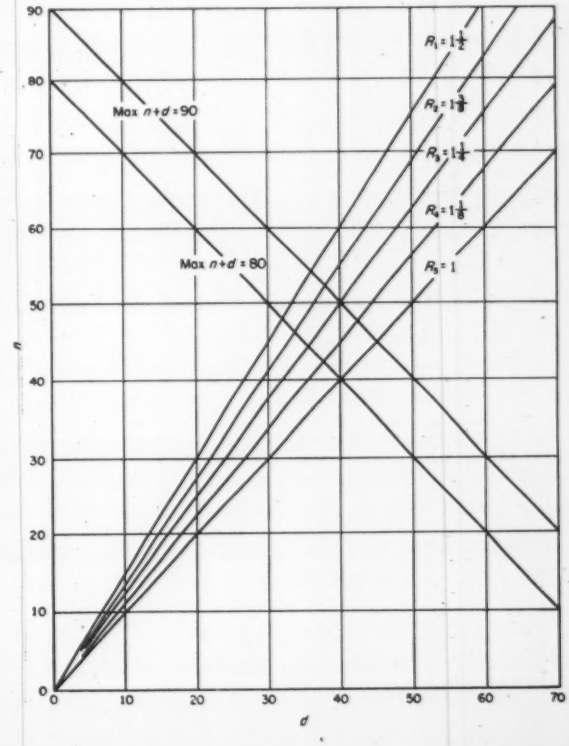
$R_7 = 10/80$ (exact)

Example 2

Problem: **Find a set of change gears to approximate the following ratios to within 1/64: $R_1 = 1\ 1/2$; $R_2 = 1\ 3/8$; $R_3 = 1\ 1/4$; $R_4 = 1\ 1/8$; $R_5 = 1$. These gears will mount on fixed centers. Choose this center distance to correspond to $80 \leqq (n + d) \geqq 90$.**

Solution: **Draw the lines representing the R's and the two diagonals, $n + d = 80$ and $n + d = 90$. Scan along each diagonal, $n + d = 90, 89, 88, \ldots, 80$, searching for the one on which fall the closest approximations to the R's. The diagonal $n + d = 90$ appears to offer the best approximations. The poorest of these, however, is $R_4 \doteq 48/42 = 1.142857\ldots$ with an error of $-0.017857\ldots$, which exceeds the stated limit, 1/64.**

Scanning the diagonals between the limits, $n + d = 120$ and $n + d = 30$ doesn't offer much hope of solving the problem by means of changing the diametral pitch. Therefore, unless gears of different diametral pitch are employed in the change-gear set, the problem is insoluble.

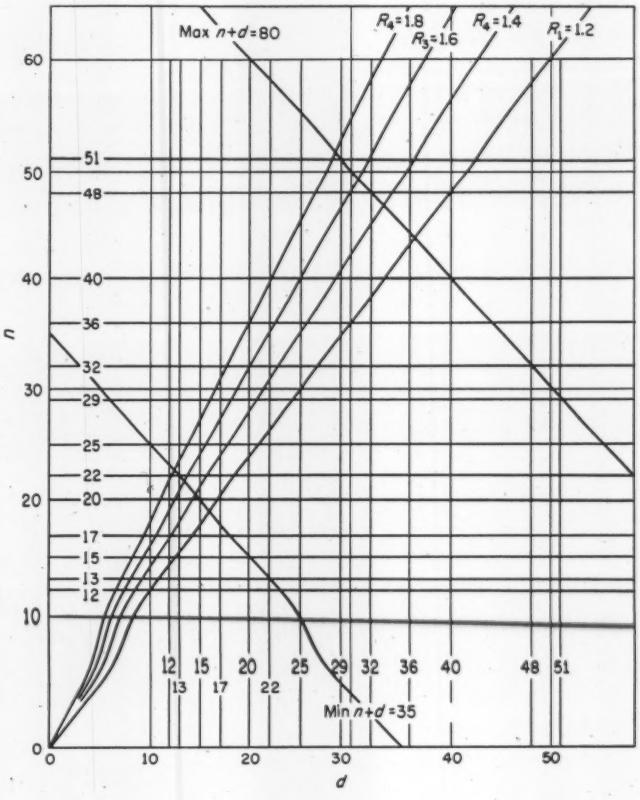


Example 3

Problem: In an existing machine, there is a set of change gears consisting of one of each of these gears; 12, 13, 15, 17, 20, 25, 29, 32, 36, 40, 48, 51. Without adding any gears to the existing set, add these ratios to those already in use; $R_1 = 1.2$; $R_2 = 1.4$; $R_3 = 1.6$; $R_4 = 1.8$. Sum of the gear teeth in any pair must be limited to a maximum of 80 and a minimum of 35.

Solution: Superimpose a lattice of lines upon the rational plane whose n and d intercepts are the numbers 12, 13, 15, 17, . . . Draw the R's and max and min $n + d$.

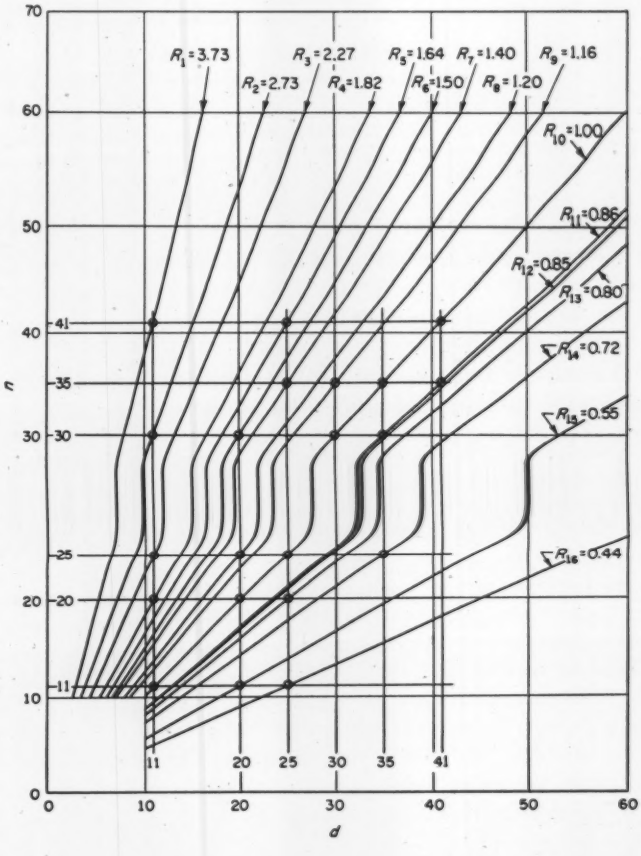
A search for points of the superimposed lattice which lie on the R's reveals these exact solutions: $R_4 = 36/20$ and $R_3 = 40/25$. For R_1 and R_2 the best approximations are: $R_1 \doteq 20/17 = 1.17647$ . . ., error $= -0.02352$ . . .; $R_2 \doteq 40/29 = 1.37931$ . . ., error $= -0.02068$ . . . If it were permissible to add two gears, 35 and 30, all R's could be made exact with $R_1 = 30/25$ and $R_2 = 35/25$.

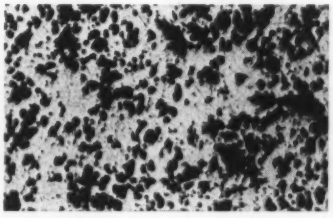


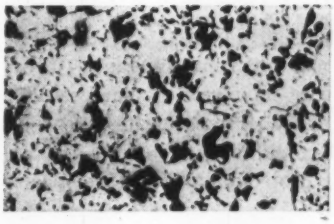
Example 4

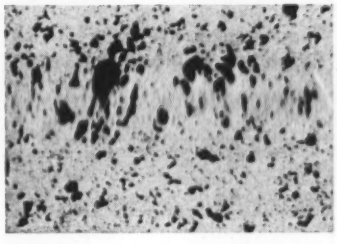
Problem: Select a set of change gears to approximate 16 given ratios, R_1 R_2, . . ., R_{16}. This can be done if the set consists of 32 gears (twice the number of ratios). However, it may be possible to use some gears in more than one combination. Find, therefore, a set containing a minimum number of gears.

Solution: Draw the lines, R_1, R_2, . . ., R_{16}. By trial and error find a minimum number of lines $n_1 = d_1$, $n_2 = d_2$, . . . which intersect as closely as desired to the R's. A set of seven gears is found. No ratio is in error by more than 0.08.









Methods of overcoming porosity for pressing and sintering

cleaning and impregnating, and

PLATING METAL-POWDER PARTS

By Charles C. Cohn
Director of Development and Research
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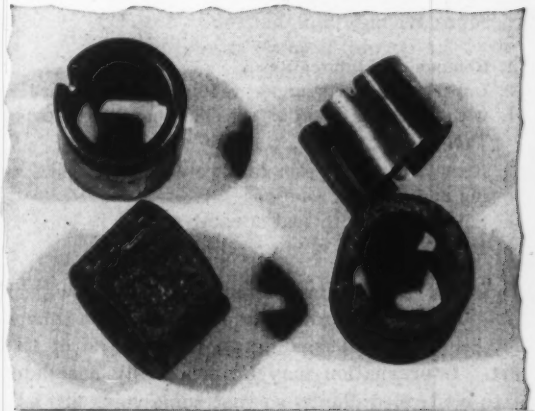
METAL-POWDER parts require special procedures for plating; regular procedures, such as used for wrought or cast parts, are not adequate.

Main problem in a metal-powder part is porosity. By contrast, porosity in a casting indicates isolated voids or areas within or on the surface. And in a conventional plated coating, porosity consists of generally uniform, microscopic pores distributed throughout the entire surface of the part.

A metal-powder part, however, is made up of fine particles of nonuniform dimensions and shape, fused to one another only on parts of their surface areas. This leaves a network of connected and unconnected channels throughout the part.

Even "high-density" metal powder parts — and parts which have been coined or pressed — have this structure, and the part still remains very porous from a standpoint of water or solution penetration.

Methods of Preparation: Plating of any part usually has two objectives: (1) pleasing appearance, and (2) protection from corrosion. Peening, tumbling or other methods of mechanical smoothing of the part prior to plating provide a more continous surface for smoother plating. But these methods do not take care of inner porosity, so the part is subject to early failure because of moisture or corrodent penetration. Plating of the green compact before sintering improves the plate from



Fuse rings of powdered iron (upper parts) have been impregnated, then plated with a 0.0003 to 0.0005-in. coating of cadmium. These components have been salt-spray tested (lower parts) for 240 hr without failure.

an appearance standpoint, but again does not increase corrosion resistance.

Another approach has been to make the internal structure water-repellent by quenching a hot metal-powder part in a silicone solution and then baking. This method has shortcomings in that porosity is still present. Pores still retain some plating or rinsing fluids which could raise havoc with subsequent plating. Additionally, the open voids permit entrance of moisture for possible corrosion if the coating has not thoroughly covered internal surfaces.

All these methods are reviewed here only to emphasize that any method of plating metal-powder parts must include some procedure for positively filling internal and external voids.

This idea is not new, and many materials have been tried. Impregnation with molten metal helps but, since pores are not filled completely, galvanic corrosion is a problem since metals are dissimilar, and differences in thermal coefficient of expansion cause internal movement which "lifts" the plate. Waxes, oils, silicates and compounds have also been tried, and most of them eliminated by trial and error.

Resin Impregnation: From this experimentation, one procedure and set of conditions has emerged as being feasible — both from the standpoint of making compacts properly plateable and providing necessary corrosion resistance. In essence, this procedure is:

1. Remove die lubricants
2. Impregnate parts under vacuum and pressure with a plastic resin of suitable characteristics, *Table* 1
3. Remove surface resin to expose metal to plating and cleaning solutions
4. Set the resin with heat or catalyst
5. Plate

Properties of the impregnating resin shown in *Table* 1 are ideal; some are necessary, but others may be ignored depending on the end-use of the part. Impregnation may be practically complete, or to controlled depths so that some voids are left unfilled.

While these steps sound simple and rather exact, the actual impregnation and plating is not so easy. In cleaning, there is always the possibility of some entrapment in the exposed surfaces (which remain somewhat porous). So certain cleaners, such as hot caustic alkalies, should be avoided. Anodic cleaning in less alkaline solutions is preferred, although this type of cleaning cannot be used on aluminum and some other alloys, since an oxide coat would form.

Technique of resin application is also critical. Parts emerging from the impregnating machine are covered with the impregnant. Excess resin on the surface must be removed, usually with organic solvents. But too much resin must not be removed, since too much porosity would be exposed. Thus, selection of the solvent and removal procedure must be exact, and depends on the resin to be removed, porosity of the original part, etc.

Parts must be plated as soon after impregnation as possible to avoid reoxidation or contamination of exposed metal surfaces. Degreasing after the solvent rinse may be necessary before cleaning and plating, since a monomolecular "oily" film is left on the parts, and this may be a barrier toward the good water wetting necessary for plating.

Plating Metals: Enough metal thickness should be deposited for utmost corrosion resistance. Once the parts have been impregnated successfully, regular plating practices and specifications can be followed without undue difficulty.

For good plating protection on iron compacts, cadmium is indicated. Nickel-plated compacts show a high degree of protection, particularly when the nickel plate is relatively free of stress cracks or porosity. In this connection, electroless nickel plating is indicated as approaching closest to the desired properties. Tin-zinc, tin-cadmium or tin-copper platings are also good possibilities for good corrosion protection.

Table 1—Ideal Properties of Plastic Resin for Impregnation

Thermosetting; high or no melting point; nonblistering when baked
All (100 per cent) solids
Low coefficient of thermal expansion
Inert or highly resistant to plating and cleaning solutions and to corrodents expected in service
Flexible; dimensionally stable
Good adhesion to metal
No effect on metal
No contamination of plating solution
Nontoxic; no objectionable odor or color
Uniformly dissolvable after impregnation to leave clean, plateable surfaces
High "filling" properties so that fluids and gases are blocked from going beyond the plateable surface planes
Little or no water absorption
Low cost
Easy to handle
No deterioration in storage
Resistant to fungus attack (if necessary)
Stable at low temperatures (if necessary)
Electrically conductive (if possible)

On copper-base compacts, a pore-free, stress-free nickel plating is desirable.

On aluminum-base compacts, anodizing — based on the latest techniques to impart the greatest corrosion resistance — is preferred. Where plating is desirable on aluminum-base compacts, a good zinc or cadmium plate is used for protection.

Where beauty or appearance is specified, a final chromium plate, preferably over nickel plate, is indicated. Finishes with excellent appearance are also possible by plating with speculum, copper-tin combinations.

Chromate or phosphate treatments over zinc or cadmium platings have been known to increase corrosion resistance and in some cases to enhance the appearance of the plating.

Calculating stresses in

Pressurized Square Tubing

having circular central holes

By A. J. Durelli and J. B. Barriage

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GEOMETRICAL and economical considerations sometimes demand that the external surface of a pressure tube be square. In order to "design" such pressure tubes it is necessary to know the stress distributions that occur when the surfaces are pressure loaded.

An analogous stress distribution occurs when a square plate with a concentric circular hole is loaded uniformly on its boundaries. Therefore, the stress distribution in such a pressure tube may be obtained by investigating the analogous square plate.

Distribution of stresses in square plates with central circular holes loaded uniformly on the interior or on the exterior boundary, or on both, is difficult to obtain by the mathematical theory of elasticity.

The solution presented here was obtained experimentally by combining the results of photoelasticity and brittle coating tests.

A square plate, *Fig.* 1*a*, is subjected to an exterior pressure P_o and an interior pressure P_i. This is equivalent to combining the results of uniform

Fig. 1—Square plate or tube subjected to interior and exterior pressure (*a*) is the sum of the conditions (*b*) and (*c*)

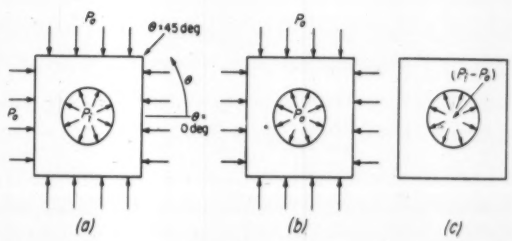


Fig. 2—Distribution of maximum shear stress along a line from center to midpoint of one side

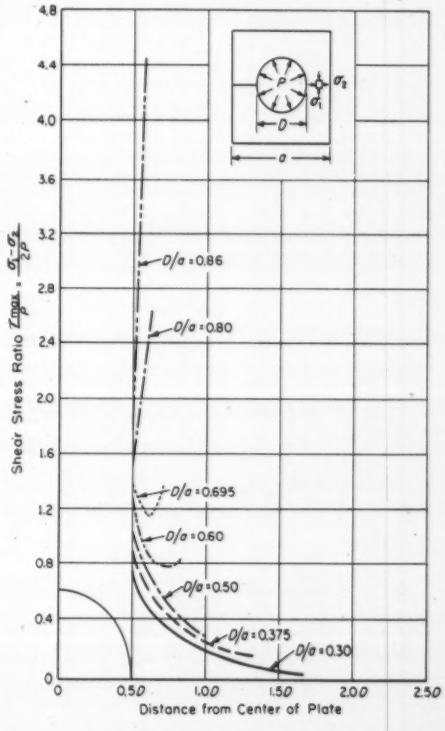


Fig. 3—Distribution of maximum shear stress along the diagonal

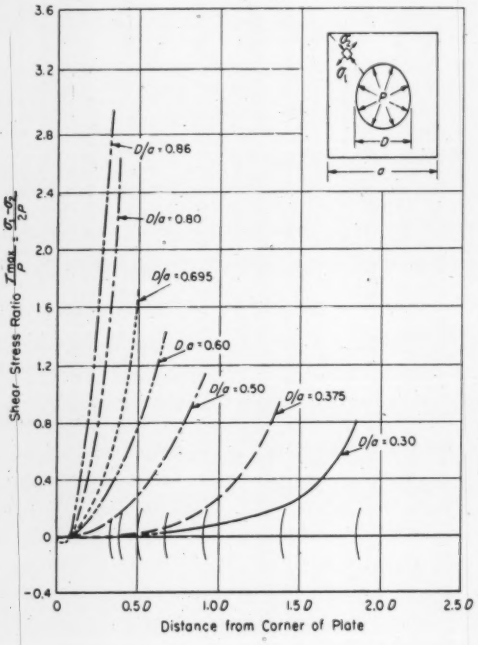
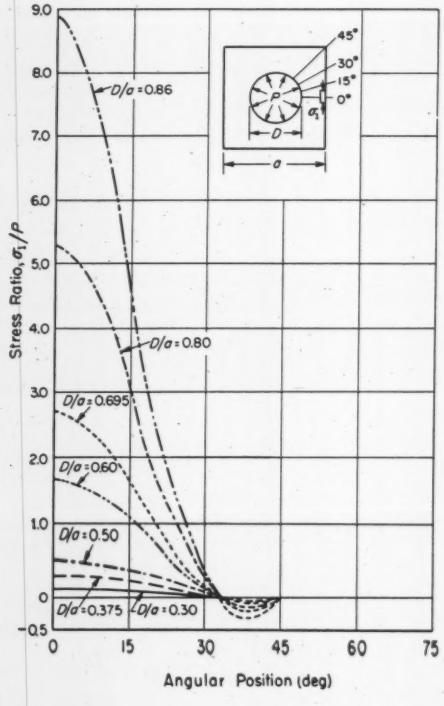


Fig. 4—Stress distribution along the side of the plate or tube



loading on both the exterior and interior boundaries with a pressure P_o (*Fig.* 1*b*), and a uniform load on the interior boundary with pressure $P_i - P_o$ (*Fig.* 1*c*).

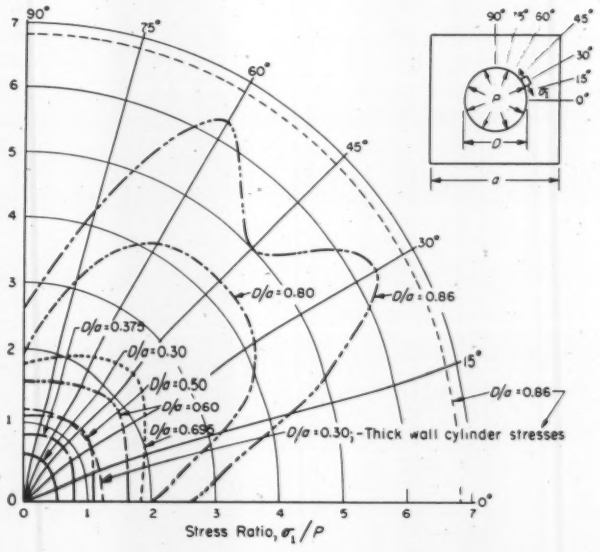
With uniform loading on both the interior and exterior boundaries, the normal stress on any plane is equal to the pressure while the shear stress is identically zero. The state of stress corresponding to a uniform loading on the interior only is given in the accompanying series of curves. In all the curves the stress is given in multiples of the effective interior pressure $P = (P_i - P_o)$. The algebraically larger principal stress is σ_1.

The maximum shear stress distribution along sections $\theta = 0$ deg and $\theta = 45$ deg, are given in *Figs.* 2 and 3, respectively, where θ is the angle between the section and a perpendicular to the exterior surface. It may be observed in *Fig.* 2 that the position of maximum shear stress along the line $\theta = 0$ deg moves from the interior boundary for the lower D/a ratios ($D/a = 0.3$) to the

Nomenclature

a = Length of side of square plate, in.
D = Diameter of hole, in.
P = Effective interior pressure, psi
P_i = Interior pressure, psi
P_o = Exterior pressure, psi
σ = Normal stress, psi
θ = Angle between section and a perpendicular to the exterior surface, deg
τ = Shear stress, psi

Fig. 5 — Stress distribution along the interior boundary



exterior boundary for the higher D/a ratios ($D/a = 0.86$).

In contrast, *Fig.* 3 shows that the position of maximum shear stress along the line $\theta = 45$ deg is always at the interior boundary and increases as the D/a ratio increases.

In *Figs.* 4 and 5, the ratio (σ_1/P) of maximum principal stress at the boundary to the internal pressure is shown for the exterior and interior boundaries of the square plates as a function of θ.

In *Fig.* 6, the stress ratio for the tangential stress at the interior boundary is plotted for $\theta = 0$ deg and $\theta = 45$ deg. Also shown is the corresponding value obtained from Lame's formula for thick-wall cylinders using D/a as the ratio of diameters. As the D/a ratio approaches zero, the effect of the shape (square versus circular) on the stress at the point considered becomes small.

For ratios of D/a less than 0.78, *Fig.* 7, the maximum shear stress is largest on the interior boundary while for D/a greater than 0.78 it is largest on the exterior boundary. At $D/a = 0.78$ the largest maximum shear stress has the same value on both the exterior and interior boundary.

Example 1: A 3½ in. square rod with a bore of 2¼ in. $D/a = 0.64$ is subjected to interior pressure P_i = 20,000 psi. Determine maximum stress.

Solution: At $D/a = 0.64$, *Fig.* 6, stress ratio is 1.55 from the curve $\theta = 0$ degrees. Stress at this point is 1.55 × 20,000 = 31,000 psi. From the curve $\theta = 45$ degrees the stress ratio is 2.1, and maximum stress is therefore 42,000 psi. For a cylinder with the same bore and 3½-in. exterior diameter, stress value is 49,000 psi, from the thick-wall cylinder curve.

Example 2: Assume an external pressure P_o of 20,000 psi on a 3½ in. square rod with a bore of 2¼ in. $D/a = 0.64$. Internal pressure, P_i, is zero. Find all of the stresses normally associated with the hydrostatic state of stress.

Solution: Since the values of shear stresses depend only upon the difference of the internal and external pressures ($P_i - P_o$), in this example $P = (0 - 20{,}000) = -20{,}000$ psi. Using *Fig.* 6, stress ratio for $D/a = 0.64$ is 1.58. Therefore $\sigma_1 = -20{,}000 \times 1.58 = -31{,}600$. Adding the hydrostatic stress of 20,000 psi gives a total tangential stress of 51,600 psi compression.

Using *Fig.* 4, the stress ratio obtained for $D/a = 0.64$ is 2.08. Then $\sigma_1 = -41{,}600$ psi. By adding the hydrostatic component, the total maximum compressive stress at the exterior boundary is 61,600 psi.

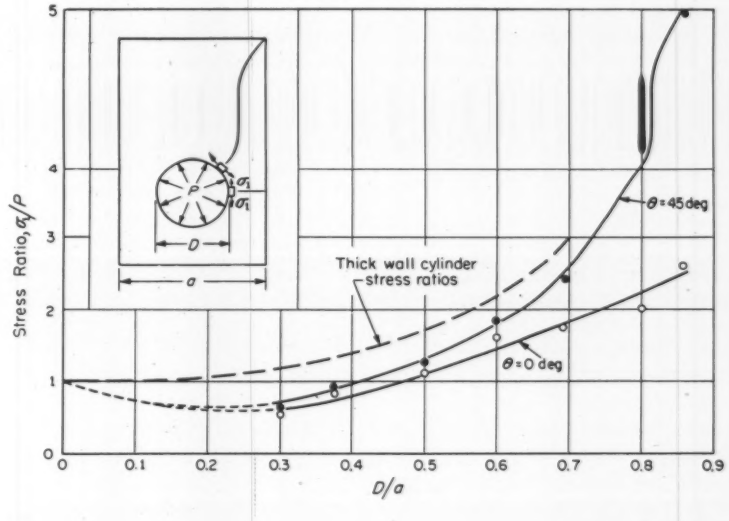


Fig. 6—Stress ratios at the lines $\theta = 0$ deg and $\theta = 45$ deg of the square plate or tube at the interior boundary

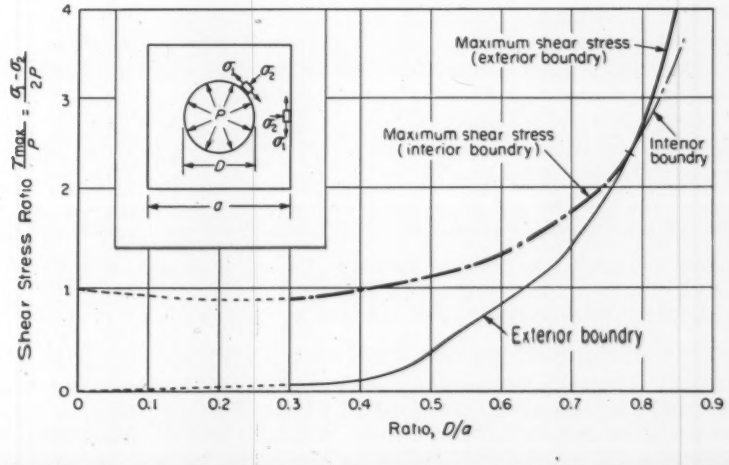


Fig. 7—Maximum shear stress in the square plate or tube

Methods and materials for making

DESIGN ABSTRACTS

Prototype Appearance Models

By Rudolph H. Koepf and Edward Ferrari

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Bridgeport, Conn.

THE appearance model fills several important needs. First, it is translation into three-dimensional substance of the flat design. It represents accumulative thinking of the entire management team. Weeks of collaborative planning effort may thus be evaluated. Also it serves to familiarize the engineer, production department and marketing people with its features and is often used to gain initial consumer reaction and provide market pretest data. Finally, it is important because it will be used as a quality standard to be obtained in production. Through the development of such appearance models, it is possible to create maximum perfection of shape, form and finish without undue restraint. Engineering test models can be developed concurrently to co-ordinate design.

It is now possible to reproduce inexpensively plastic casts of a new appearance design which can be handled by many people or shipped to distant points during the process of development of the production item. Additional casts of a new design can be supplied to the engineer to be used by him in building test models.

This technique of producing plastic molded parts represents a cost saving over the old method of having to hog the part out of a solid block material such as phenolic, wood, or metal, or casting it in metal with the resulting finishing problems. Through the use of this method, it is possible to produce rugged plastic prototypes which not only resemble, but are in many cases as durable as the production item.

Four different types of molds are involved in this process. The first is a rigid plaster mold, the second a rigid, reinforced plastic mold, the third a flexible mold, and the fourth an electroformed mold.

Plaster Molds: When it is necessary to cast a few pieces only, a plaster mold will serve economically. The simplest type of plaster mold is made in one piece. The model is placed on a level surface or background. A flash or fence is then built around the model, allowing enough space for the mold thickness. After applying a parting agent to the assembly, it is filled with successive layers of Hydrocal plaster and reinforcing burlap. When the plaster is set, the flask and mold are removed from the model.

In the case of a piece mold, the parting lines are determined. Each piece is made individually by placing a fence on the parting line. After the first piece is made, the fence is removed and the adjacent pieces are molded one against the other. When all the pieces are made, they are capped in a matrix in which they are nested. Keys are notched into each piece to insure their proper location. A parting agent insures the removal of each piece from the other and from the model.

If a cored or hollow cast is necessary, the mold is reassembled. The wall thickness necessary in the cast is established by placing sheet wax or clay on the inside face of the mold. A plaster core which is related to the outer piece mold is poured in the remaining cavity formed by the wax or clay. The core is then removed from the mold, also the wax or clay. The space between the core and mold is the cavity which will be filled by the resin.

Plastic Molds: A plaster mold is not very durable; it is subject to damage during the process of removing the casts. Consequently, when the cast to be produced can be poured in a rigid mold and many casts are desired, a reinforced mold made of one of the cast plastic materials is preferable.

Calcerite: Calcerite consists of finely divided amino resins which are catalyzed by a liquid catalyst. This material is mixed in the same manner as plaster. Five parts of the powdered resin are mixed with one part catalyst. This material can be reinforced with glass fiber, sisal fiber or wire mesh as desired. It works equally well in molds or casts. In the mold form it is very suitable for casting epoxy resins.

Flexible Mold Materials: When intricacies of design require fine details such as texture, embossed or debossed lettering and numerals, a flexible mold is sometimes advisable. There are a number of flexible mold materials to choose from, and each serves an individual necessity. They are grouped into four different types consisting of natural rubber latices, cold-molded polysulfide and silicone rubbers, hot-melt vinyls, and heat-fused plastisols and elastomeric vinyls.

Natural Rubber Latices: The

natural rubber latices are applied by a series of coatings either dipped, sprayed or brushed. Each coat is allowed to dry out before the next one is applied and reinforced with a layer of cheese cloth or filled with cotton flock. When the rubber which is self-vulcanized is thoroughly cured, it is backed up with a plaster mother mold or case. Some are compatible with polyester resins, and some are not, depending on whether or not they contain free sulphur compounds which inhibit the cure of the resin. The process of making a rubber mold is slow, and the mold is subject to shrinkage and, consequently, a loss of accuracy in the cast.

Polysulfide Synthetic Rubbers: The polysulfide synthetic rubbers consist of three compounds: synthetic latex, a curing agent, and a catalyst. When mixed, they cure into a solid but flexible mass at normal room temperature. The procedure with this material is to coat the model with a parting agent. The catalyzed rubber is then spread over the model with a brush to an even thickness. After it has cured, a plaster matrix is poured over it. Since there is no heat involved in this method, it is useful in transposing a clay or plasteline model directly into plastic.

Silicone Rubbers: This material can be applied to the model with a spatula to the desired thickness and is backed up with a plaster matrix. It consists of two compounds, one of which catalyzes the other when mixed, and is known as Silastic.

Although synthetic rubber compounds have good dimensional stability, they are weak in structure and are, therefore, not too well suited for multiple casting.

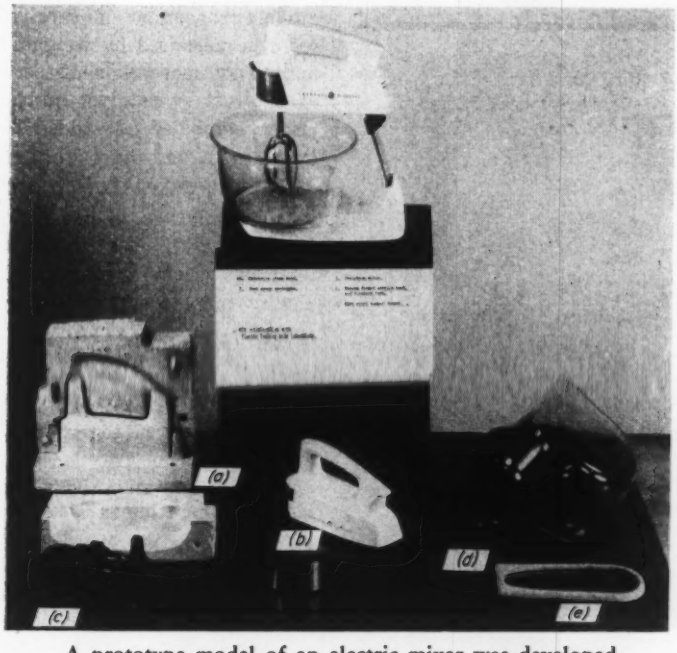
Flexible Vinyl Mold Materials: Flexible vinyl mold materials can be classified in three different types: the plastisols and elastomers in the cold-poured, heat-cured vinyls, and the hot-melt vinyls.

Plastisol Molds: The plastisol molds are made by fastening the model to a background. A fence or rail is placed around the model and thoroughly sealed against leakage. The plastisol is then poured over the model until it is totally covered to a suitable depth above the highest point of the model. The assembly is then placed in an oven at 350 to 365 F and cured. If necessary, a plaster back can be poured over the mold before removing it from the pattern. The pattern must be made of a nonporous material capable of withstanding the curing temperature of the plastisol. This type of mold has good tensile strength and is well suited for casting all types of resins.

Elastomer Molds: The elastomeric vinyls are poured in an open mold in the same manner as is used in making plastisol molds. However, it is possible to pour and cure the elastomer on a model made of porous materials such as wood or plaster. Because the elastomeric vinyls have this property, it is possible to make large molds in this material. In order to do so, a plaster matrix or case is first made over the model. A space is created between the model and the case into which the elastomer is poured and cured. This is accomplished by means of the following steps:

Strips of plasteline, ¼-inch in thickness, are pressed onto the model until they make contact with all of its surface. To this layer of plasteline, cylinders of plasteline are added at each of the highest points to serve later as pouring gates and vents. Over the plasteline a plaster shell is made using A-11 Hydrocal plaster reinforced with AA mosquito netting. When this plaster case has set it is removed from the model. The plasteline is also removed. The case is then thoroughly dried and waxed with paste wax to insure parting from the elastomer. The case is then replaced on the model and fastened to the background. The elastomer is poured into the gate until the assembly is filled and is then placed in an oven at 220 F to cure or fuse the elastomer. When the mold is cured it is allowed to stand until thoroughly cooled and is then removed from the model.

If the model is already cored out, the second half of the mold is made by removing the model



A prototype model of an electric mixer was developed from these items, which include: *a*, Calcerite piece mold; *b*, cast epoxy part; *c*, prototype motor; *d*, vacuum-formed acrylic bowl and Furatone form; and *e*, cast vinyl bumper gasket

from the background and placing it back into the mold cavity on the first half. The same procedure is then used in making the second half as was employed in the first.

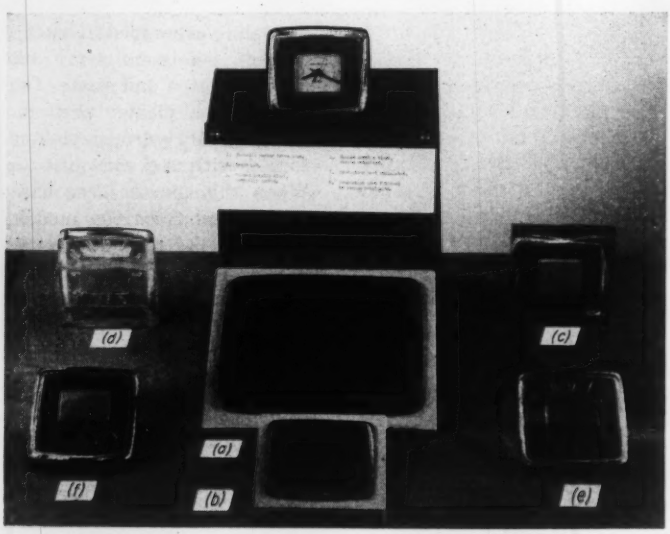
If the original model is solid and it is necessary to core it out and re-establish bosses and webs, this can be done at the same time that the second half of the mold is being planned. Plasteline or wax of the wall thickness desired in the model is placed on the surface of the mold cavity of the first half. A plaster cast is then made in the remaining cavity formed by the wax or plasteline. This cast is related to the case of the first half. This cast is removed when it is set, as is the thickness of wax from the original mold cavity. This cast is the model for the core.

A plaster mold is now made directly on this model. The surface of this mold cavity is then covered with strips of plasteline, and a plaster case is again made over it. This case and the plasteline are removed. The case is returned to the mold, and the space formerly occupied by the plasteline is filled with elastomer and cured. This is the second half of the mold with all the requirements of the core surface of the model registered on it.

Hot-Melt Vinyls: This same system is used when a hot-melt vinyl is used for the flexible part of the mold. The procedure used is first to evacuate as much as possible the air in the space to be filled. This is done by sealing all openings in the case and applying a vacuum pump. Melted vinyl is then pumped into the case containing the model. When the vinyl has thoroughly cooled, the case is removed and the vinyl is cut at the parting line of the mold and stripped from the model. It is then replaced in each half of the case.

This material is used where the molds are very large, and the fact that it can be remelted constitutes a definite economy. Also, this type of mold is dimensionally very stable and has very good resistance to tearing.

Casting Resins: The type of casting resin used in model and prototype work is determined by the conditions existing in its end use. Phenolics are used where heat resistance and dimensional stability are necessary. Reinforced polyesters are best suited to large castings requiring good impact strength but need not be dimensionally critical. Epoxy resins are used where impact strength must be reasonably high and good dimensional stability is important but resistance to heat is not necessary. The furans exhibit good dimensional stability and resistance to constantly high temperatures; also, their resistance to impact is good and can be controlled. Clear cast polyesters are used where transparency is the prime objective. They are dimensionally poor, but the shrinkage can be precalculated and compensated in the model.



These parts used in making a prototype model of an urban clock include: *a*, phenolic master, twice size; *b*, brass hob; *c*, hobbed acrylic block, vacuum metalized; *d*, hobbed acrylic block, partially carved; *e*, unfinished production part; and *f*, production part finished by vacuum metalizing

Casting Techniques: Phenolic resins used for the purpose of casting are a product by condensation of phenol with formmaldehyde. The reaction of this combination continues and therefore limits their shelf life. Refrigeration at 42 F tends to retard this continued reaction and extends the usefulness of the resin.

Polymerization is produced by the addition of a catalyst and the application of heat, 120 to 150 F. A cold-setting mixture can be produced by adding an accelerator in addition to a catalyst. The accelerator produces sufficient internal heat to effect the cure of the resin at room temperature.

The proportion of catalyst to resin is measured by weight. Normally, not more than 10 per cent of catalyst or catalyst and accelerator combined are added to the liquid resin, and thoroughly mixed, care being taken not to stir air into the mixture. Some phenolics are used with cork and asbestos filler in order to strengthen them, usually not more than 10 per cent of the total mix.

After the resin and catalyst have been mixed together, a few drops of alcohol are placed on the surface of the mix. This will assist in liberating any entrapped air which rises to the surface. Also, a little alcohol is placed in the mold cavity prior to pouring; this will reduce the tendency for bubbles to form on the surface of the cast. After the resin has been poured into the mold, it is allowed to harden to a gel stage and, if necessary, heat is applied to complete the cure. Parting agents are

necessary to insure removal of the cast. They may be any good paste wax or silicone in either spray or jelly form. The mold, if plaster, should be first sealed with a good sealing lacquer or shellac before applying the parting agent. If the mold is of the flexible type, a light coat of wax or silicone will facilitate the removal of the cast. The mold assembly should be allowed to cool thoroughly before removing the cast.

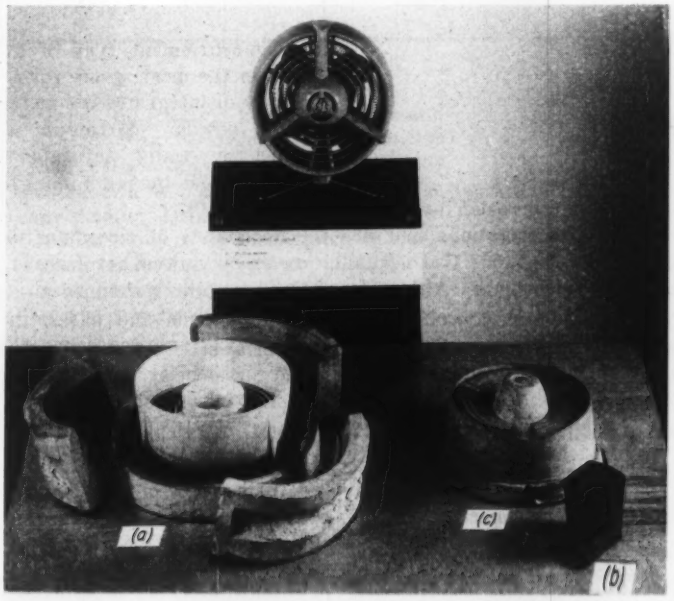
Furan Resins: Furan resins are basically of two types; furfural alcohol and furfural ketone combinations. The furfural alcohol combinations are catalyzed by the addition of activated silica. The furfural ketone combinations are polymerized at low temperature into a solid casting which is highly resistant to scratching, heat and chemicals. Polymerization is produced by the addition of a catalytic extender. The shelf life at room temperature is indefinite since there is no reaction within the resin until catalyzed.

When this combination is used for casting, 65 parts of dry catalytic extender are added to 100 parts resin by weight. This mixture is stirred thoroughly until all of the catalyst has been mixed with the resin. A few drops of alcohol are placed on the surface in order to assist the liberation of entrapped air in the resin mixture. The mixture is allowed to stand until it begins to gel, then poured into the mold. The mold can be closed, with a pouring gate and adequate vents. However, best results are obtained by pouring into open halves of a two-part mold and allowing the resin to reach a degree of gelation which will permit pressing the two halves together without having any run-off.

This results in a compressed casting which is denser and free from any surface imperfections in the cast. The cast may be cured in the mold by heat, with temperatures ranging from 150 to 300 F, dependent upon the mixture used. The mold and cast should be allowed to cool before removing the cast. The cast will be dimensionally stable and can be buffed to a lustrous black finish. It can be subject to a constant temperature of 375 F.

Epoxy Resins: The most commonly used epoxy resins are a combination of bisphenol-A and an epoxy compound, principally epichlorohydrin. This resin is cured with a variety of hardeners of the amine or acidic type. Each producer of this type of resin has his own proportions of hardener to be added to the resin. Some need heat in order to complete their cure. In all cases the hardener is added to the resin, stirred, and allowed to stand as long as possible to permit any entrapped air to escape.

Unles the epoxy resin has been specially compounded, not more than 3/8-inch thickness should be cast at one time. Otherwise, exothermic reaction will be too high, causing the curing cycle to be too rapid. This is apt to result in a high shrink factor. Combining fillers in the resin such as micas, calcium carbonates, chopped glass, etc., will tend to reduce this reaction and impart better physical characteristics to the castings. Epoxies can be plasticized to produce a flexible compound for use in molds for casting epoxies or other resins. Their heat resistance can be raised to 360 F by using a curing agent such as metaphenyline diamine or HET anhydride. Further developments in this direction are in the laboratory stage. The process of treating the mold is the same as that described in the casting of phenolic and furan resins.



Parts for a fan heater consist of: *a*, molded fan shell in parted mold; *b*, tooling master; and *c*, mold core

Polyester Resins: Polyester resins are normally used in a reinforced state. Glass fibers, either in mat form or woven cloth, are incorporated in the resin in a series of layers known as a wet lay-up. In some cases a mixture of fillers and short glass or asbestos fibers are combined to make a putty-like mixture which is then compressed into a mold. Polyesters are catalyzed by the use of benzol peroxide agents in the form of benzol peroxide in tricresylphosphate or methy ethyl ketone peroxide in dimethyl phthalate. Cobalt napthanate is combined with the agents to insure the surface cure of the cast when certain types of polyesters are used.

Mold preparation varies according to the type used. A plaster mold must first be sealed with a good lacquer, then waxed, then sprayed with a mold parting agent in order to insure proper release

of the cast from the mold.

If a plastisol mold is used, no parting agent is necessary. However, if an elastomeric vinyl is used, the same parting agent film used on a plaster mold is sprayed on the surface of the elastomer mold. The reason for this is that the free styrene monomer content in the polyester resin tends to draw the plasticizer from the vinyl which, in turn, inhibits the surface cure of the cast.

Hot-melt vinyls are similarly treated with a coating which is baked on. This coating contains the surface finish required in the cast and becomes integral with it.

Clear Cast Polyesters: Clear cast polyester resins are of the allyl type; they are mixed and poured in the same manner as used with reinforced polyesters. Mold preparation is also the same. The casts can be sanded and buffed to produce a high degree of translucence. The material is useful in casting clear knobs and objects which must resemble glass.

Fabricating: Cast plastics can be machine ground, engraved, cemented, hobbed and postformed. The acrylics can be cut to shape and cemented. Temporary metal dies can be made for hobbing. This is accomplished by first heating a block of acrylic to approximately 225 F, and placing it in a flask with the die positioned over it with guide pins. The assembly is then placed in a hydraulic press and compressed until the die bottoms on the flask. When the assembly has cooled, the molded acrylic block is removed from the die. Special hobbing acrylics are now compounded for this purpose.

Vacuum Forming: Thermoplastics such as the acrylics, high-impact polystyrenes, acetates, butyrates, vinyls and polyethylene are used in vacuum-forming techniques. Male molds used in drape forming can be made from metal, Masonite, wood or plaster. Some are now being made from reinforced epoxy and cast furan resins. Cast resins of this type are also used in female molds for decorative pieces.

Electroplating and Electroforming: Electroplating on nonmetallic surfaces is a process which is employed to produce the appearance of a metal part. It is possible to do this on plastic, plaster or wood models.

The process of electroforming is similar to electroplating. However, there are two essential differences. The plating is done into a mold instead of over a surface. Consequently, the finished surface will be the one which is in contact with the mold. Therefore, the sequence of plating is nickel, then copper until the desired thickness of part is achieved. The part is then stripped from the mold, trimmed to the parting line, buffed to a high polish and chrome plated in the conventional manner.

Electroformed cavities are achieved by the same process employed in electroplating, except that the rate of deposit is increased and the plating time is lengthened considerably. When the cavity has reached the desired thickness, it is removed from the model and is polished to a high luster. If necessary, it can be encased in a cast plastic block. The cast plastic parts produced in this mold will have the appearance of a molded plastic part.

From papers entitled "Model Making Techniques at General Electric, Small Appliance Division" and "From Design to Prototype Model" presented at the 11th Annual Meeting of Society of Industrial Designers in Washington, D. C., October 1955.

Characteristics of

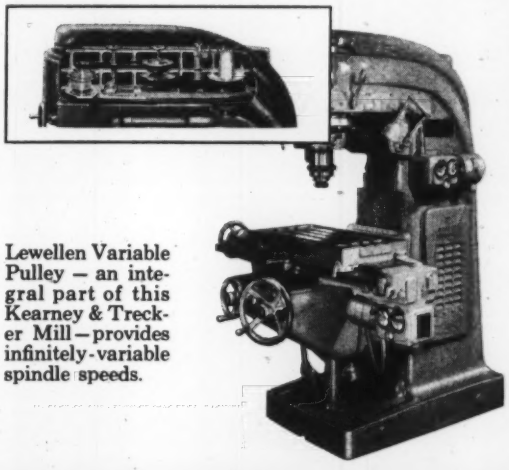
Zirconium

IN METALLURGICAL structure zirconium is similar to magnesium, titanium, zinc, and chromium. Zirconium has frequently been used to resist attack by hydrochloric acid. It also has excellent resistance to most other corrosives.

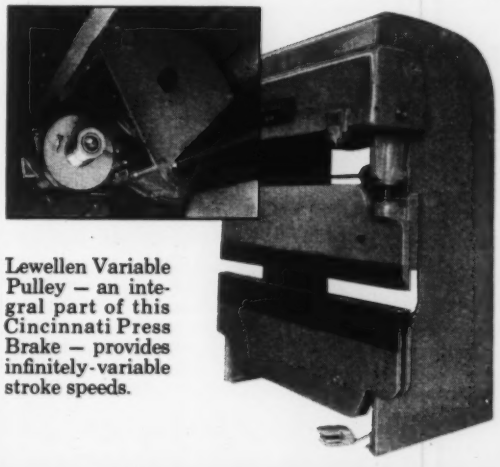
Zirconium resists the action of all cold mineral acids and, also, alkalies at all temperatures and concentrations. It has excellent corrosion resistance at all temperatures in sulphuric acid solutions up to 80 per cent concentration by weight. Above this point there is a sharp increase in the rate of corrosion, especially in hot acid. Zirconium resists corrosion by nitric acid of all concentrations and at temperatures to 100 C. Aqua regia attacks zirconium. Although nitric acid in any concentration does not attack it, the addition of a small amount of sulphuric acid to the nitric acid destroys the corrosion resistance. Zirconium is fully resistant to all concentrations of phosphoric acid up to 60 C, and up to 60 per cent concentration by weight at 100 C.

None of the metal-chloride solutions affect zirconium with this exception: ferric and cupric chloride, with which zirconium suffers an embrittlement type of attack. This in the most severe form completely disintegrates the metal into a fine powder. Zirconium is corroded by water saturated with chlorine and by red fuming nitric acid.

Resistance of zirconium to corrosion by various hot gases is poor. However, its resistance to corrosion by acids and bases, its mechanical strength, wear resistance, and low density make it especially useful in orthopedic surgery for special surgical applications. No known compound of zirconium has a toxic effect on the body. Bone and tissues will adhere to this metal. Zirconium may well replace tantalum in orthopedic surgery. It apparently has all of the advantages of tantalum plus a much lighter weight. The specific grav-



Lewellen Variable Pulley – an integral part of this Kearney & Trecker Mill – provides infinitely-variable spindle speeds.



Lewellen Variable Pulley – an integral part of this Cincinnati Press Brake – provides infinitely-variable stroke speeds.

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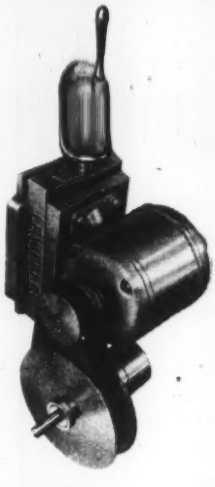

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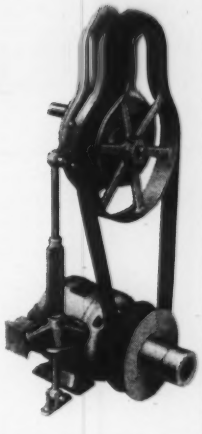
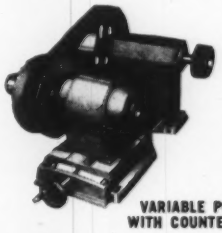
NEED SLOW MACHINE SPEEDS?

Drive to shaft-mounted reducer. Turnbuckle adjusts centers – and speeds – motor base is eliminated. Lewellen Variable Pulley and other standard components equip the power package... compact – economical – accessible.

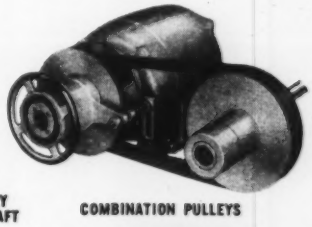


Lewellen Variable Pulleys and accessories are versatile power components that perform smoothly and dependably—installed in any position and operated in any manner. Drive to sheave (Kearney & Trecker Mill) or flywheel-clutch (Cincinnati Press Brake) as well as pulley, flat or crown face. Selection of ratings, speeds, centers permits widest latitude for incorporating variable speeds. 300 Series Lewellen Variable Pulleys scale to new N. E. M. A. motor frames, also fit old frames. 300 Series offer 40% space savings, 50% overhung load reduction.

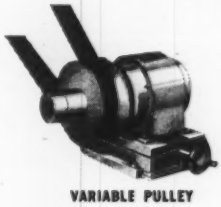
Write for Variable Pulley Catalog No. 60
... Transmission Catalog No. 65



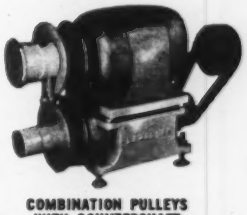
VARIABLE PULLEY WITH COUNTERSHAFT



COMBINATION PULLEYS



VARIABLE PULLEY



COMBINATION PULLEYS WITH COUNTERSHAFT

LEWELLEN MANUFACTURING CO., COLUMBUS, IND.

DISTRIBUTORS IN ALL INDUSTRIAL AREAS • IN CANADA—PEERLESS ENGINEERING SALES LTD., TORONTO – MONTREAL

—ITEM 207—

ity of tantalum is 16.6, and that of zirconium 6.4, *Table* 1.

Behavior in Fabrication: Zirconium can be cast, rolled, forged, extruded, formed, drawn, spun, arc welded, spot welded, brazed and machined successfully. Like titanium, zirconium is very susceptible to absorption of, and alloying with, oxygen, hydrogen, and nitrogen at high temperatures. Therefore, working temperature must be carefully regulated. Fortunately, however, the hot working of zirconium can be successfully accomplished at temperatures well below the critical temperatures for gas absorption.

Table 1—Specific Gravities of Metals

Metal	Specific Gravity
Magnesium	1.74
Aluminum	2.7
Titanium	4.5
Zirconium	6.4
Zinc	7.14
Iron	7.86
Copper	8.92
Lead	11.34
Tantalum	16.6
Platinum	21.45

Zirconium ingots have been forged at 1600 F. Unlike magnesium, the rate of forging is not critical. It can be press forged in hydraulic machines, or can be forged equally well by steam or air hammers. Initial working must be done with light blows to break up the cast structure.

Rolling is done hot down to thicknesses of 0.040-inch to 0.050-inch. In cold rolling, zirconium work hardens rapidly during the first 10 to 20 per cent reduction, after which work hardening proceeds at a much slower rate. Zirconium can be extruded successfully into rod, tubing and shapes. Some difficulty is encountered due to its tendency to seize the die wall. Colloidal graphite lubricant is generally used on the die to minimize this tendency.

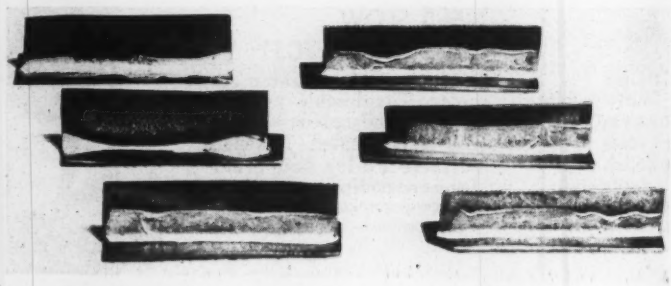


Fig. 1— Samples of zirconium brazed by Wall Colmonoy Corp.

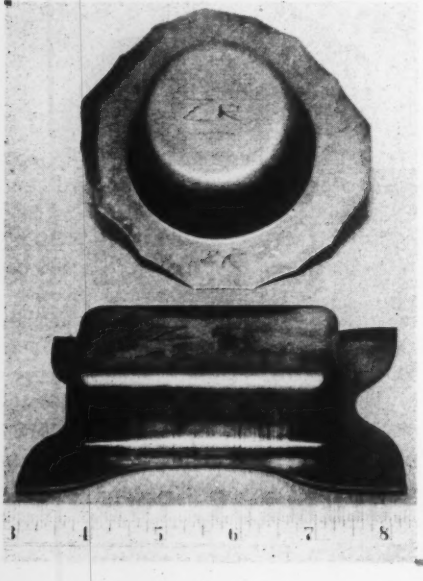


Fig. 2 — Zirconium parts hot drawn in a single operation

Brooks & Perkins have successfully arc welded and spot welded zirconium. Arc welding is done by the helium or argon shielded arc process. Comparative weld strengths are quite similar to those obtained with other metals. A method of furnace brazing zirconium, using a specialized vacuum technique, has been developed by Wall Colmonoy Corp., *Fig.* 1. Furnace brazing is successful using either silver or silver-manganese alloy as brazing material.

Machining of zirconium is similar to that of pure copper or stainless steel. It is best machined with a coolant; however, it can be machined dry at a speed of 100 feet per minute, cutting to a depth of ⅛-inch and a feed of 0.032-inch per revolution. Higher speeds can be used when the tool and work are cooled with an air blast or a liquid coolant. Although zirconium cuts freely, it is tough and abrasive to the tool. Cutting tools should be kept very sharp, since dull tools work harden zirconium rapidly. Because of the soft, tough characteristics of zirconium, a low operating speed is recommended for drilling and grinding. Zirconium tends to adhere to a grinding wheel in a manner comparable to aluminum and brass.

Like magnesium and titanium, zirconium can be easily hot drawn in a single operation to greater depths than aluminum, brass, or steel, *Fig.* 2. With pure zirconium, successful draws are made in a hydraulic press at about 650 F, using colloidal graphite lubricant on the blank to prevent seizing. Deep drawing in a single operation eliminates the necessity for staging dies and for intermediate anneals. The same type of die used for magnesium or titanium is used for zirconium. Techniques are very similar.

Essentially the same fabrication techniques for rubber forming, press brake forming, roll forming, stretching, etc., used for magnesium and titanium are also used successfully for zirconium.

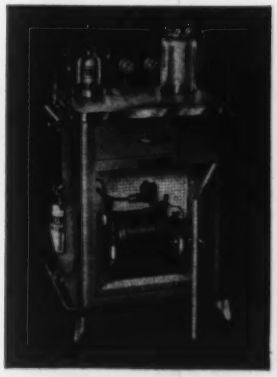
From "Zirconium," in the Magazine of Magnesium, *published by Brooks & Perkins Inc., August* 1955.

Leland motors here can't fail

The explosion-proof, motor-driven suction and ether unit in a modern operating room *can't fail.* It must pump highly volatile ether to maintain anesthesia, and drain excess body fluids literally to prevent drowning!

Leland engineers—working closely with the J. Sklar Manufacturing Company ...helped obtain the *first and only U.L. Approval ever given an electrically driven apparatus of this type!*

Electric motors? *Leland* knows how to make them. And to tailor them to your specific needs. For the answer to an unusual problem, or information on the complete line of quality motors from ⅛ to 5 hp—soon to 20 hp—in all standard types and enclosures, contact us today.



Class I, Group C Underwriters' Approved explosion-proof Leland Motor dependably powers this dual-purpose Sklar hospital unit.

Another AMF Product

LELAND MOTORS

THE LELAND ELECTRIC COMPANY

Dayton 1, Ohio

Division of AMERICAN MACHINE & FOUNDRY COMPANY

—ITEM 208—

For More Information Circle Item Number on Yellow Card—page 19

HELPFUL LITERATURE

for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Fluid Agitators

Design and performance information on the new integrated packaged Philadelphia line of fluid agitators is contained in bulletin A-255. This equipment is usable for blending, mixing, contacting, dissolving, dispersion and other operations. 6 pages. Philadelphia Gear Works, Inc.

—Circle ITEM 1

Vacuum Valves

Engineering drawings, cut-away and exploded views and specifications for series of bronze, cast iron and fabricated steel bellows-sealed vacuum valves are found in bulletin 401. Models cover temperature range from −125 to 350° F. 6 pages. New York Air Brake Co., Kinney Mfg. Div.

—Circle ITEM 2

Variable Speed Air Motors

Compact 1-hp variable speed air motors for continuous or intermittent duty applications are subject of illustrated data sheet 71. Motors can be used to power wide range of equipment. 2 pages. Gardner-Denver Co., Keller Tool Div.

—Circle ITEM 3

Constant Force Spring

Design data for the Flex'ator compression spring which exerts the same force at any deflection is presented in engineering bulletin 313A. It discusses spring characteristics and properties, materials, types of ends, mounting and gives four tabulated design charts. 12 pages. Hunter Spring Co., Flex'ator Div.

—Circle ITEM 4

Hydraulic Components

Many of HydrOILic pumps, motors, controls and pumping units briefly described in illustrated bulletin 146 are built for circuit pressures up to 5000 psi. Others are rated at 2000 to 3000 psi. Design features are given. 4 pages. Denison Engineering Co.

—Circle ITEM 5

Solenoid Valves

Two technical data sheets deal respectively with Bulletin 8314 midget packless solenoid valves and bulletin 8210A-8211A corrosion-resistant solenoid valve. Designated forms V5010 and V5006, they provide pressure ratings, flow conditions, construction and operational data. Automatic Switch Co.

—Circle ITEM 6

Lubricants for Open Gears

Type 165X near-colloidal dispersion of Molykote Microsize in a viscous, tacky and adhesive oil is rendered fluid by a volatile diluent. It is an extreme bearing pressure lubricant. Type LOEX diester dispersion is suited for extreme low temperature applications. Both are described in bulletin 105. 2 pages. Alpha Molykote Corp.

—Circle ITEM 7

Flexible Metal Hose

Full range of Flexon flexible metal hose products are descriptively covered along with complete coupling data in illustrated catalog 152. An easy four-step metal hose selection guide is included. Hose is made with both annular and helical corrugations. Burst pressures range up to 16,000 psi. 12 pages. Flexonics Corp.

—Circle ITEM 8

High Resistance Meter

Details of the type 1862-B megohmmeter which gives test voltages of ½ to 2,000,000 megohms at 500 v and ½ to 200,000 megohms at 50 v are presented in illustrated application and specification bulletin 873-A. 4 pages. General Radio Co.

—Circle ITEM 9

Liquid Level Transmitter

Just how the type 12 LA d/p cell liquid level transmitter can be used to measure the equivalent of up to 250 in. of water is explained in bulletin 13-22. Device is usable in closed tanks and requires only ½-in. pipe connections. Design and operating features are shown. 8 pages. Foxboro Co.

—Circle ITEM 10

Data on V-Belts

Data folder 5-403 covers BFG grommet V-belts, high capacity grommet V-belts, static conducting belts, oil-resisting V-belts and double V-belts. Grommet belts feature load-carrying cords concentrated in twin grommets, or cord loops. This construction extends belt life and increases strength for severe service. 4 pages. B. F. Goodrich, Industrial Products Div.

—Circle ITEM 11

Colloidal Dispersions

Forty-two colloidal and semicolloidal dispersions of graphite, molybdenum disulfide, mica, vermiculite, zinc oxide and acetylene black with various carriers and diluents are described in bulletin "A List of 'dag' Dispersions for Industry". 4 pages. Acheson Colloids Co.

—Circle ITEM 12

Production Facilities

This company's facilities for producing stampings, screw machine products and copper brazed assemblies are described briefly in illustrated folder. 6 pages. Steel Industries, Inc.

—Circle ITEM 13

Electric Terminal Block

Pres-SURE-block heavy duty terminal blocks are furnished assembled or in sections ready for assembly into any length for No. 18 to 4 wire with electrical ratings from 5 to 70 amp. Tubular screw, tubular clamp and strap type contacts are available. Ask for bulletin PB. 4 pages. Buchanan Electrical Products Corp.

—Circle ITEM 14

Piston Packings

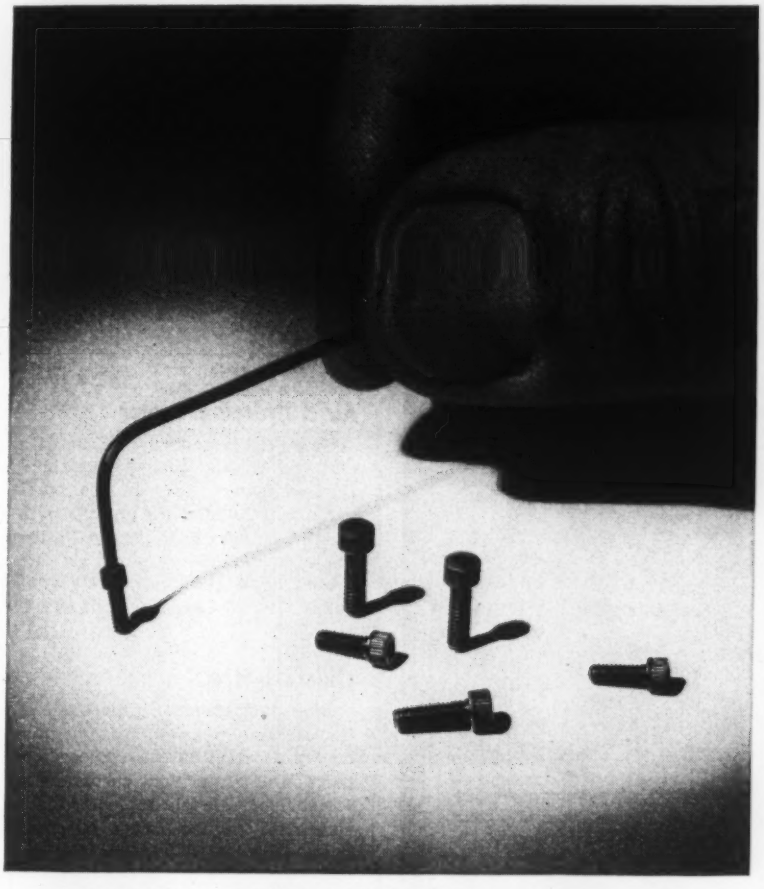
Complete data and design information on Darcova Pumcups for packing pistons of air and hydraulic cylinders and reciprocating pumps are tabulated in bulletin 5503. Typical installations, properties of compositions and application data are included. 16 pages. Darling Valve & Mfg. Co.

—Circle ITEM 15

Diesel Engines

What is a diesel? What are the advantages of turbocharging? How does a turbocharger work? How has turbocharging been applied to Cummins diesels? Answers to these and related questions are found in illus-

Miniature screws aid standardization of small devices



Standard UNBRAKO miniature socket head cap screws are available in sizes # 0, # 1, # 2 and # 3, in heat treated alloy steel or stainless steel, at your authorized industrial distributor's. Standard lengths range from ⅛ to ½ in.

Tiny close-tolerance Unbrako screws available in standard sizes

New economies in the design of space-saving miniature equipment are possible with these UNBRAKO miniature socket head cap screws. Manufactured to timepiece precision, available locally, they save the costly necessity of designing special screws to fasten tiny parts in compact units. They're ideal for use in typewriters, calculators and computers, servomechanisms, electric and electronic equipment—and in countless other small, intricate devices where maximum reduction in bulk and weight is required with no sacrifice in strength of individual components or assemblies.

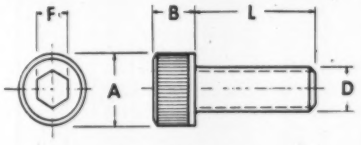
Fingers grip the knurled heads on these tiny screws positively for easy handling and fast assembly. Uniform hex sockets assure maximum wrenching torque. Controlled fillets under the heads prevent shearing of the heads. Threads are fully formed for maximum strength and exact fit. Extremely accurate head diameters permit their use in countersunk holes, saving weight by reducing the length of the screw required and making flush designs possible.

These standard UNBRAKO miniature screws are available at your authorized industrial distributor's. See him today. Or write us for Bulletin 2055 and samples. Unbrako Socket Screw Division, STANDARD PRESSED STEEL Co., Jenkintown 18, Pa.

See us at Booth 479—ASTE Show

HEAT-TREATED ALLOY STEEL

Class 3 Fit Standard



	Diameter	Threads per Inch NC	Threads per Inch NF	Length	Recommended Installation Torque in Inch-Pounds NC	Recommended Installation Torque in Inch-Pounds NF	Weight per 1000 in Pounds
#0	A .104		80	⅛		2.0	.152
	B .060		80	3/16		2.0	.182
	D .060		80	¼		2.0	.210
	F .050		80	⅜		2.0	.265
#1	A .118		72	⅛	3.5	3.5	.27
	B .073		72	3/16	3.5	3.5	.32
	D .073		72	¼	3.5	3.5	.37
	F .050		72	⅜	3.5	3.5	.47
#2	A .140	56		3/16	6.0	6.0	.42
	B .086	56		¼	6.0	6.0	.50
	D .086	56		⅜	6.0	6.0	.58
	F 1/16	56		½	6.0	6.0	.70
#3	A .161	48		3/16	8.5	9.5	.59
	B .099	48		¼	8.5	9.5	.70
	D .099	48		⅜	8.5	9.5	.81
	F 5/64	48		½	8.5	9.5	1.03

Standard Screws are threaded to the head. Special materials, lengths, and threaded lengths are available. One "High-Titan" UNBRAKO hex key is included with each package of 100 screws.

UNBRAKO®

SOCKET SCREW DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA

—ITEM 209—

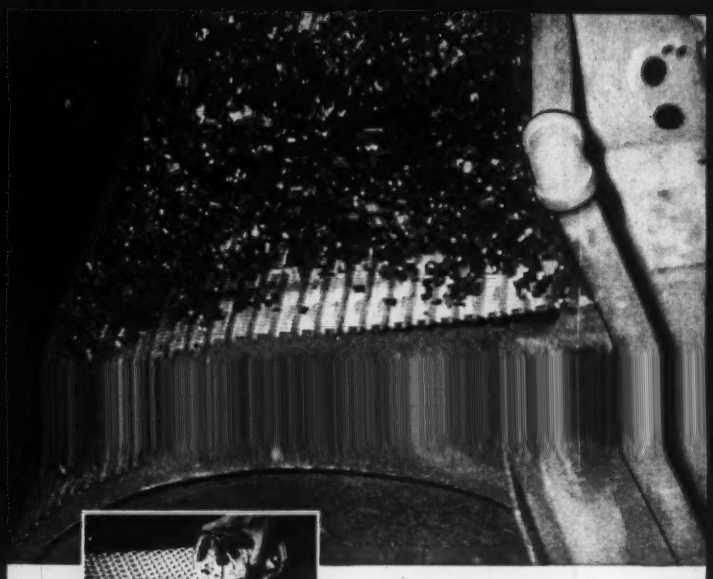
For More Information Circle Item Number on Yellow Card—page 19

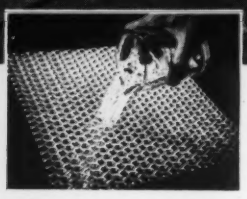
Cambridge

WOVEN WIRE CONVEYOR BELTS

take the bottlenecks out of

WASHING, DRYING, PACKAGING





OPEN MESH of rustproof, all-metal belt provides free circulation of process solutions and drying air; assures waste-free packaging.

Whether you're processing slab, sheet or pelletized materials . . . or packaging bottles, drums or bags . . . Cambridge Woven Wire Conveyor Belts combine movement with processing. Continuous belt-to-belt flow through washing and drying cycles, roasting kilns, and weighing and sealing operations cuts cost and provides controlled uniform production.

REGARDLESS OF YOUR INDUSTRY . . .

. . . metalworking, food, chemical, ceramic or glass . . . whether the machines are for your own operation or resale, you'll find "open mesh" only one property of Cambridge belts that makes combined movement and processing practical and economical. Open mesh construction also provides rapid drainage of process solutions. Belts are corrosion resistant and impervious to heat damage, even at 2100°F. They have no seams, lacers or fasteners to wear more rapidly than the body of the belt. Cambridge Woven Wire Belts are made in any size, mesh or weave; from any metal or alloy. Special surface attachments are available to hold products during inclined movement.

Call in your Cambridge FIELD ENGINEER to discuss how you can cut costs by continuous operation. Look under "BELTING, MECHANICAL" in your classified phone book. OR, write for FREE 130-PAGE REFERENCE MANUAL giving mesh specifications, design information and metallurgical data.

The Cambridge Wire Cloth Company

WIRE CLOTH · METAL CONVEYOR BELTS · SPECIAL METAL FABRICATIONS

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OFFICES IN PRINCIPAL INDUSTRIAL CITIES

Helpful Literature

trated bulletin 12009. Specifications are given for 175 to 600-hp Turbo-diesels. 16 pages. Cummins Engine Co.

—Circle ITEM 16

Dripproof Motors & Generators

Illustrated specification sheets GEC-1372 and 1373 deal with Kinamatic industrial dripproof direct current motors and generators. Former are available in ½ to 150-hp sizes, while latter are made in ¾ to 100-kw sizes. 4 pages each. General Electric Co.

—Circle ITEM 17

Air & Hydraulic Power

Over 700 standard models of air and hydraulic components enable this company to offer the correct valve and cylinder for any air or hydraulic circuit. Full details of these valves, cylinders and power units are presented in fluid power bulletin. 4 pages. Rivett Lathe & Grinder, Inc.

—Circle ITEM 18

Stainless Steel

Blue data sheet on type 301 stainless steel suggests applications of this austenitic steel with a nominal composition of 17 per cent chromium and 7 per cent nickel. It is usable for structural applications, automobile trim, show cases and cooking utensils. Properties are listed. Allegheny Ludlum Steel Corp.

—Circle ITEM 19

Engineered Gears

Facilities and typical gearing products engineered and manufactured to meet user's needs are outlined in illustrated bulletin AC 503. Listed are machines for hobbing, shaping, shaving, grinding, cutting, lapping and testing various types of gears. 8 pages. Sargent Engineering Corp.

—Circle ITEM 20

Bronze Valves

More than 250 different sizes and styles of low pressure, pressure rated and flared tube bronze valves, including a new line of solder and threaded end swing check valves, are listed in catalog NVC-2. Information on weights, dimensions and shipping quantities is furnished. 28 pages. Northern Indiana Brass Co.

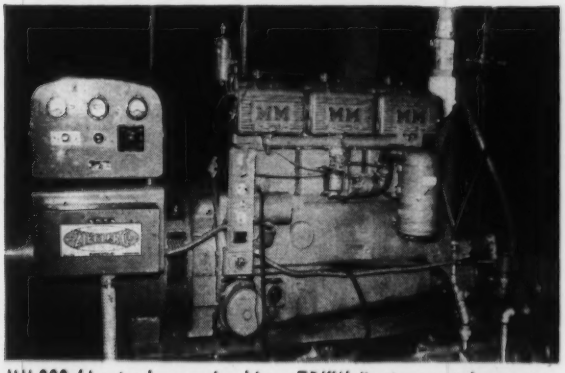
—Circle ITEM 21

Permanent Magnet Materials

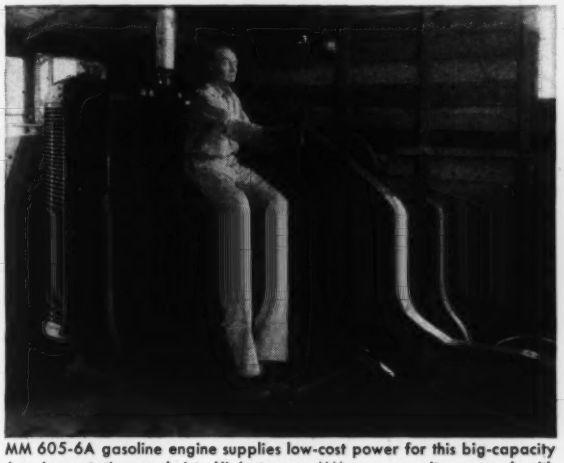
A practical guide for designers to "Permanent Magnet Materials and Their Selection" is provided by manual 5-R of this title. Cast, sintered, ductile and formed magnet materials are discussed and their characteris-

High-Production Equipment deserves Honest HP

MM 283-4A gasoline engine powering a Lindig Soil Shredder. Compact, easily installed MM engines provide a permanent, integral power source for a wide range of portable equipment.



MM 800-6A natural gas engine drives a 75 KW direct-connected generator. Equipped with automatic remote control, this unattended stationary plant supplies regular or standby power.

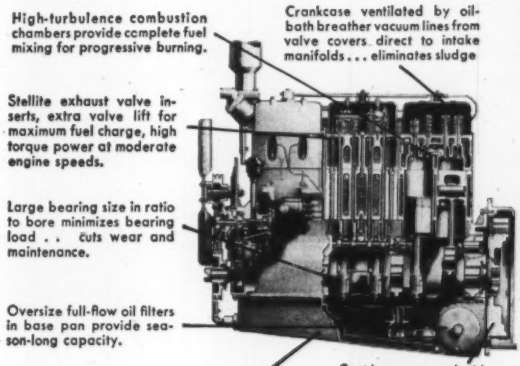


MM 605-6A gasoline engine supplies low-cost power for this big-capacity American stationary hoist. High torque MM power units respond with steady rpm to intermittent or changing loads.

MM 403-4A gasoline engine mounted on a Warner-Swasey Gradall. Choice of gasoline, diesel, LP gas, natural gas or distillate fuel equipment offers continuous-duty MM power at lowest fuel costs.

Here's how MM builds Honest HP

MINNEAPOLIS MOLINE
MODERN MACHINERY


High-turbulence combustion chambers provide complete fuel mixing for progressive burning.
Crankcase ventilated by oil-bath breather vacuum lines from valve covers direct to intake manifolds . . . eliminates sludge
Stellite exhaust valve inserts, extra valve lift for maximum fuel charge, high torque power at moderate engine speeds.
Large bearing size in ratio to bore minimizes bearing load . . cuts wear and maintenance.
Oversize full-flow oil filters in base pan provide season-long capacity.
Thermo-clad water-blanketed base pan and by-pass cooling maintain uniform top-to-bottom engine temperature.
Cast base pan and wide flywheel flange give effective 360° rear main bearing support. Crankcase extends nearly 4 inches below crankshaft center line.

Honest horsepower is horsepower developed at operating speeds that are practical for heavy continuous duty. That is why Minneapolis-Moline engines are designed to develop maximum torque at around 1000 rpm and are power rated at from 1200 to 1400 rpm. Deep-pocket, high-turbulence combustion chambers for progressive fuel burning and prolonged pressure combined with large displacement and high compression ratios enable MM engines to deliver work-type power at usable speeds. Where special installations require higher rpm with rapid acceleration, MM engines can be furnished with aluminum pistons.

MM engines are stocked in various fuel models and standard equipment bundles for quick delivery. You can buy bare engines, engines with radiator, fan and power take-off, or complete enclosed units. Modification of standard units on separate production runs to meet special requirements are part of the flexible MM operation that saves you time and money.

If your design calls for long-run industrial engine power that will last the life of the equipment, we will be pleased to furnish a prompt quotation and shipping date for a pilot model built to your specifications.

MM ENGINE SIZES

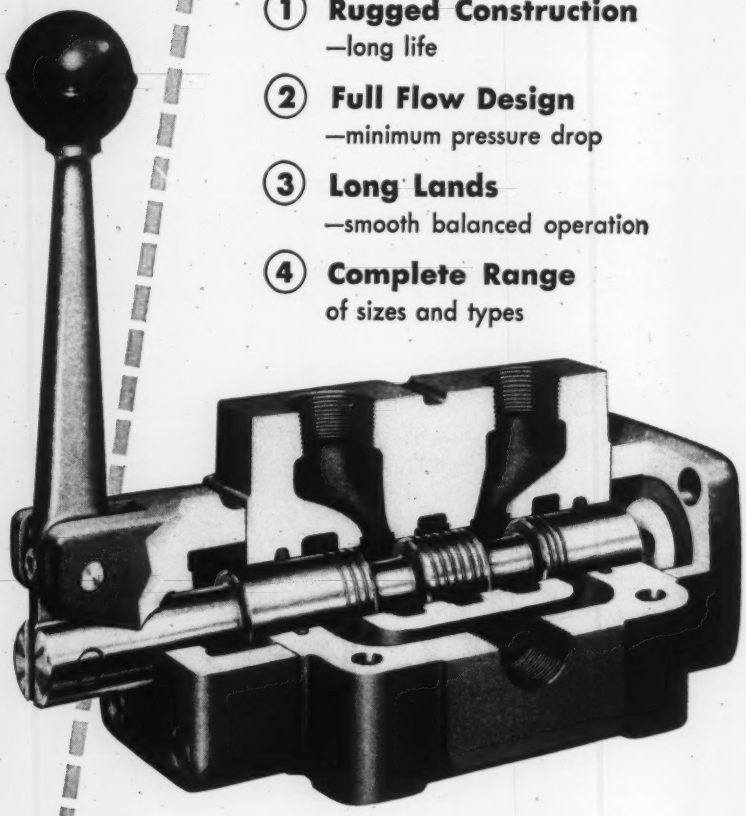
4 Cylinder Carbureted Models*		6 Cylinder Carbureted Models	
MODEL 206A-4A	3⅜" x 5"	MODEL 425-6A	4¼" x 5"
MODEL 283-4A	4¼" x 5"	MODEL 605-6A	4⅝" x 6"
MODEL 403-4A	4⅝" x 6"	MODEL 800-6A	5⅝" x 6"

*Engineered for gasoline, distillate, natural or LP gas.

4 Cylinder Diesel Models		6 Cylinder Diesel Models	
MODEL D-283-4A	4¼" x 5"	MODEL D-425-6A	4¼" x 5"
		MODEL D-605-6A	4⅝" x 6"

MINNEAPOLIS-MOLINE
INDUSTRIAL DIVISION
MINNEAPOLIS 1, MINNESOTA

4-way cost control



① **Rugged Construction**
—long life

② **Full Flow Design**
—minimum pressure drop

③ **Long Lands**
—smooth balanced operation

④ **Complete Range**
of sizes and types

H-P-M Directional Control Valves meet most demands for unqualified heavy-duty service. That's why economy minded design engineers choose time-tested, job-proved H-P-M

hydraulic valves and controls for every

hydraulic requirement in the 2000-3000 psi range. Heavy distortion-free bodies, smooth operating spools, wide choice of operating characteristics are available. Write today for complete catalogs—¼" to 4" sizes.

HPM

HYDRAULIC POWER DIVISION
THE HYDRAULIC PRESS MFG. CO.
Mount Gilead, Ohio U.S.A.

—ITEM 212—
For More Information Circle Item Number on Yellow Card—page 19

Helpful Literature

tics summarized. A glossary of magnetic terms and symbols is featured. 12 pages. Indiana Steel Products Co.

—Circle ITEM 22

Miniature Ball Bearings

The 1955-56 edition of the Miniature Ball Bearing catalog tabulates dimensions, load ratings and engineering data on complete line of miniature ball bearings ranging from 1/10-in. to ⅜-in. OD. 24 pages. Miniature Precision Bearings, Inc.

—Circle ITEM 23

Stainless Plunger Rings

Data sheet describes tempered and treated stainless steel plunger rings designed for die casting machine operation. Rings will withstand operating temperature to 1200° F. 2 pages. Precision Piston Rings, Inc. of Indianapolis.

—Circle ITEM 24

Switches

Data sheets 104 and 105 respectively describe a small two-circuit Micro limit switch and a double-pole double-throw environment-free switch. Former is for industrial application, while latter is used on landing gears, flaps or other exposed locations of aircraft. 4 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div.

—Circle ITEM 25

Steel Hardness Tables

Approximate relationship between Brinell, DPH (Vickers), Rockwell and Shore Scleroscope hardness values and corresponding tensile strengths of steels are given on this 2¾ x 4¾-in. celluloid card. International Nickel Co.

—Circle ITEM 26

Seamless Welded Fittings

Types and size ranges of alloy, carbon and stainless steel seamless welded fittings are furnished in folder FB-500. Types of flanges are also pictured. 6-pages. Babcock & Wilcox Co.

—Circle ITEM 27

Air Motors

Two sizes of explosionproof air motors with ratings from ½ to 4 hp are described in illustrated bulletin 855. Speeds are variable with valve control and rotation is in either or both directions. Specifications are given. 2 pages. Gast Mfg. Corp.

—Circle ITEM 28

Polyester Film

Third issue of "New Developments in 'Mylar' Polyester Film," is a

Pushed for Greater Drafting Room Output?
Modern Reproduction Machines Will Help You Get It!

NOW Is the Time to Get Your New, Modern BRUNING COPYFLEX MACHINE!

The boom in production means more pressure than ever for engineering drawings and prints. Right now is the time to replace that old inadequate reproduction machine you've been putting up with — now's the time to get a modern, efficient Bruning Copyflex.

In just the last year, Bruning has introduced five new, advanced machine models, one of which is shown at the right. These machines offer you the famous problem-free installation and operation of Copyflex . . . no exhaust venting, no plumbing or auxiliary equipment, no installation other than an electrical connection. They bring you faster reproduction speed and a host of operator conveniences such as fast return of originals, automatic separation, front or rear delivery. They are the efficient, economical, modern reproduction machines that will help you boost your drafting room output, keep costs at a minimum.

Now is the time to act. Mail the coupon below. You'll be glad you did!

Copyflex Model 500
A new, ultra-fast, heavy-volume machine offering top mechanical speed of 40 f.p.m., automatic separation, front or rear delivery, automatic stacking, and a host of other advanced features.

BRUNING Copyflex

Best Process! Best Machines!
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Specialists in Copying Since 1897

CHARLES BRUNING COMPANY, INC., 4700 Montrose Ave., Chicago 41, Illinois
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Charles Bruning Company, Inc., Dept. 33-K
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Please send me information on Copyflex process and Model 500 machine.

Name _____ Title _____
Company _____
Address _____
City _____ County _____ State _____

—ITEM 213—
For More Information Circle Item Number on Yellow Card—page 19

For the design engineer, Morganite is a material with a vast potentiality. Its properties are unique. They can be varied to obtain specific characteristics.

Morganite parts are lighter than aluminum and, of course, are non-corrosive. A wide variety of shapes can be molded or, where necessary, intricately machined to a high degree of accuracy.

Morganite carbon is self-lubricating . . . has high resistance to wear . . . a wide range of resistance to chemical attack . . . is not wetted by molten metals or slag . . . is non-seizing, non-galling . . . retains good mechanical strength at high temperatures . . . has low thermal expansion . . . and has good electrical conductivity.

Why not send us the details of your design problem. Our Engineering Staff will welcome the opportunity to work with you.

50th ANNIVERSARY 1906 · 1956

Morganite INCORPORATED

Manufacturers of fine carbon-graphite products for fifty years.
3314 48th Avenue, Long Island City 1, New York

—ITEM 214—

Helpful Literature

pocket-size publication which presents latest applications for Mylar. Booklet points up automotive, luggage, decorative yarn, electrical and other uses of this clear plastic film. 22 pages. E. I. du Pont de Nemours & Co.

—Circle ITEM 29

Fire Protection

"Engineered Special Hazard Fire Protection" is an illustrated brochure which covers the generally accepted methods of fire detection, prevention, control and extinguishment associated with special hazards. Various special hazards are described and specific equipment for use with them is covered. 28 pages. "Automatic" Sprinkler Corp. of America.

—Circle ITEM 30

Silicone Products

1956 reference guide to silicone products describes almost 150 of the most generally used silicone products, eight of which are only a year old. Products are grouped by physical form and cross-indexed by their usage, which includes dielectrics, defoamers, damping media, etc. 12 pages. Dow Corning Corp.

—Circle ITEM 31

Tube Fittings

Nylo-Seal tube fittings of DuPont Zytel nylon can be used with stainless steel, nylon, polyethylene, aluminum, copper or other tubing. Described in illustrated bulletin 3049, they withstand temperatures from −70 to 250° F. Types and sizes are covered. 4 pages. Imperial Brass Mfg. Co.

—Circle ITEM 32

V-Belts

Among subjects covered in illustrated manual on care and maintenance of industrial V-belts are designing the new drive, double matching, installation, how V-belts grip, importance of tension, alignment, how to clean and storage. Chart shows causes of failure. 12 pages. B. F. Goodrich Co.

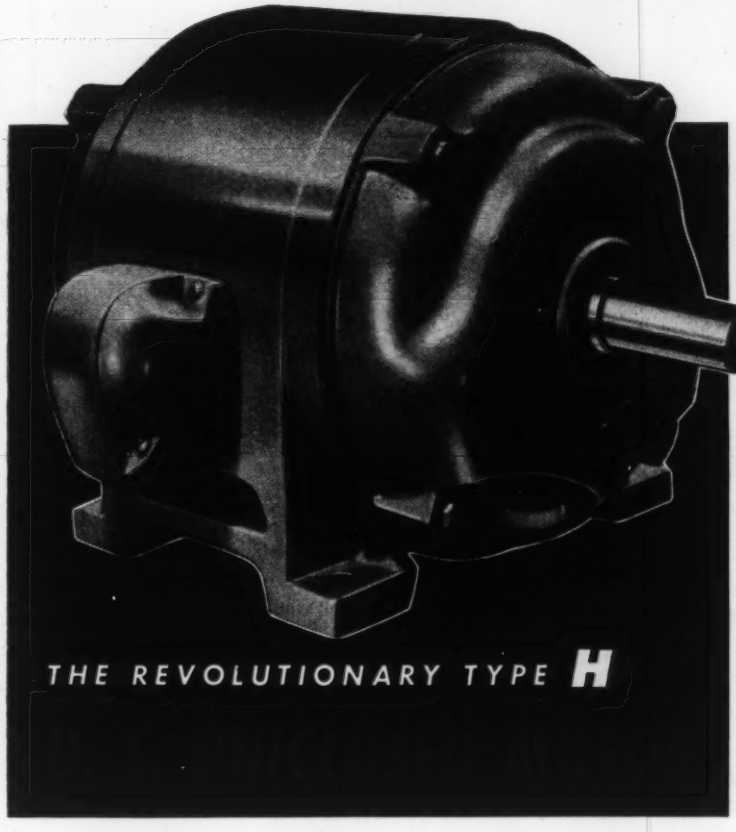
—Circle ITEM 33

Speed Reducer

Design details of type HVUT universal change-gear conveyor drive are found in illustrated folder. Mounting can be in a variety of positions. With standard 50:1 worm gear reduction, total ratios between 50:1 and 1800:1 can be realized. Torque control is explained. 6 pages. Philadelphia Gear Works, Inc.

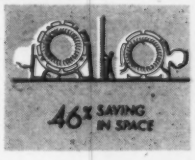
—Circle ITEM 34

more motor than ever before...



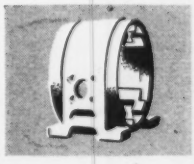
more HORSEPOWER

Type H is most compact. The same horsepower is provided in a "smaller package." An actual saving in space of 46% for the 2 h.p. size.



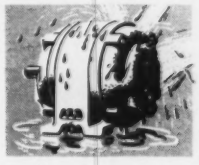
more RUGGED

The cast-iron frame defies distortion. The smooth cast-iron surface is highly corrosion-resistant. The heavy solid feet on the Type H are a substantial part of the frame.



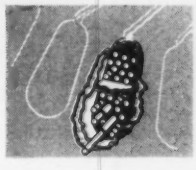
more PROTECTION

Ventrifoil directs air, deflects water. Each end of the motor has a specially formed deflector which directs air around bearing housings and into fans on the rotor.



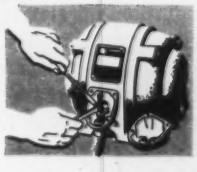
more INSULATION

U.S. multiple protection increases insulation life. ASBESTOS—for protection against heat. SILICONE—for moisture resistance. MYLAR—for greater physical strength.



more CONVENIENT

The spacious conduit box is a heavy-duty cast-iron, diagonally split type, attractively contoured and very easy of access.



New-fashioned power is the result of more and more exclusive and valuable features present only in this new motor. They include asbestos insulation to resist heat and moisture; Lubriflush bearing construction for longest life; Ventrifoil baffles to direct air and deflect water; solid cast-iron frame and normalized castings, all directed to the objectives of longer motor life and more efficient power.

A profusely illustrated multicolor bulletin fully describing construction features of the Type H motor is available. Write for your copy today.

U.S. Electrical MOTORS

MAIL COUPON NOW

MD-3

U. S. ELECTRICAL MOTORS Inc.
P. O. Box 2058, Los Angeles 54, Calif., or Milford, Conn.
Send Type H Bulletin No. F-1856

Name_____

Company_____

Address_____

City_____ Zone_____ State_____

—ITEM 215—
For More Information Circle Item Number on Yellow Card—page 19

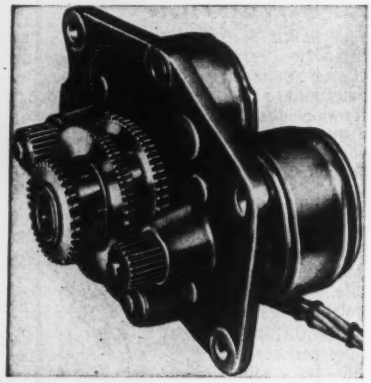
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Digital Shaft Pulser

converts current pulses to analog shaft positions

Current pulses are used to actuate this digital shaft pulser, which rotates six degrees per pulse. Translating digital pulses to analog shaft positions, the unit can be used to remotely actuate counters, multipoint switches, and similar devices. Applications are also found in automation and data processing. The current pulse required is 80 ma for 10 millisec, and pulse rates



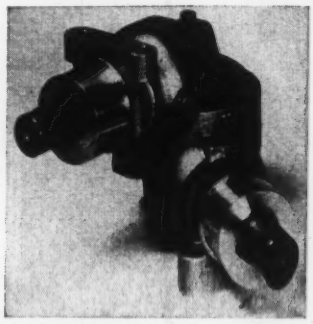
to 40 per second can be accepted, depending on the load. With the addition of simple gear combinations to the basic unit, the step increment per pulse can be increased to 36 deg. Accuracy of shaft positioning is $\pm\frac{1}{2}$ deg. Dimensions are $3\frac{1}{2}$ x $2\frac{1}{4}$ x $2\frac{1}{2}$ in. **Newton Co.**, 55 Elm St., Manchester, Conn.

—Circle ITEM 61

Geared Joint

transmits torque through 45 to 315-deg angles

Designed to transmit control-linkage torque around sharp corners this geared joint operates at any angle from 45 to 315 deg. It can



also be used to transmit power at shaft speeds to 500 rpm. Efficiency has been increased 60 per cent over former models by the use of needle bearings. Either flexible shafts or rigid rods may be used with the joint. Maximum operating torques are 500, 2000, or 3500 lb-in., depending upon the model selected. **Stow Mfg. Co.**, 11 Shear St., Binghamton, N. Y.

—Circle ITEM 62

Air Volume Booster

improves response times of pneumatic equipment

Small changes in signal pressures initiate large changes in flow volume of series 4500 air volume booster. Designed to shorten response times of air cylinders or

similar air-operated equipment, the unit initiates a flow output change with less than one inch of water variation in signal pressure. Flow capacity is 115 cfm when signal pressure is 10 psi and supply pressure is 50 psi. With 150-psi supply, capacity is 170 cfm. Small volume of signal chamber permits use of low-capacity signal sources and provides high frequency response characteristics. Boosters are available for $\frac{3}{8}$, $\frac{1}{2}$, and $\frac{3}{4}$-in. pipe sizes. **Bellofram Corp.**, Governaire Div., Burlington, Mass.

—Circle ITEM 63

Nylon Screws and Nuts

in lengths to $1\frac{1}{2}$ inch

Black nylon screws and nuts are molded in lengths to $1\frac{1}{2}$ in., thread sizes from 6-32 to $\frac{1}{4}$-20, and in both flat and round-head types.

Resistant to corrosion and nonconducting, the screws need no washers or bushings in electronic or chemical application. **Weckesser Co.**, 5261 N. Avondale Ave., Chicago 30, Ill.

—Circle ITEM 64

Precision Potentiometer

generates sine-cosine functions

Starting torques less than 0.5 oz-in. and 0.05 deg maximum backlash are provided by series BC-200 function - generating potentiometer. Sine-cosine unit is available from

thanks to ACCUMET PRECISION INVESTMENT CASTINGS

This bolt-making machine transfer arm used to be machined from a forging of SAE 1045 steel. A grooved pin had to be machined and assembled in the forging, and many milling, broaching and drilling operations were needed to produce the finished part.

Then a Crucible ACCUMET® precision investment casting was tried, using heat-treated SAE 4140. Results? All machining except drilling and tapping two small holes was eliminated. Better functional design was achieved. A more rugged grade of steel was used. The manufacturer's machine tools were released for other jobs.

This is just one example of hundreds where ACCUMET precision investment castings have improved the design, function and performance of a component part – *with a reduction in cost.* It was possible because Crucible – the country's leading specialty steel producer – has established standards of quality and uniformity in its ACCUMET precision castings that are unsurpassed in the industry.

So look over the machining operations in your shop. Take an *extra* long look at the intricate products that are made in many costly, high-reject steps. Then let your Crucible representative show you how ACCUMET precision investment castings can help you lower costs and improve your products. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 12, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

XUM

CASE HISTORY 1

REQUIRED:
A dependable supply of this small, machined electrode to meet customer's quality and quantity needs at reduced cost.

HASSALL SOLUTION:
Hassall-designed re-heading process, involving no critical dimension changes, resulted in a 59% cost reduction to customer.

CASE HISTORY 106

REQUIRED:
Replacement for stud with insufficient head to act as stop for automatic hammering.

HASSALL SOLUTION:
Substitution of Hassall cold-headed collar nail with annular threads for greater holding power. Substantial cost savings.

CASE HISTORY 64

REQUIRED:
An economical method of manufacturing perforating punches out of hard materials such as drill rod.

HASSALL SOLUTION:
The Hassall cold-heading process plus engineering skill overcame the difficulties presented by these alloys at considerable savings.

CASE HISTORY 37

REQUIRED:
Bumper bolt with bonded rubber cap for license plate support.

HASSALL SOLUTION:
The large head on this bolt would ordinarily call for screw machining but the two lugs under the head ruled this out. Progressive cold-heading was Hassall's answer.

SPECIALTY MANUFACTURER OFFERS SAVINGS ON SMALL PARTS AND FASTENERS

Multiply these case histories a thousandfold and you'll get some idea of the variety of tough problems we crack, and the savings we effect for our customers in the course of a year.

Our cold-heading process—supplemented by secondary operations—imposes amazingly few limitations on the parts and fasteners we can make. Don't forget that we are not limited to "stock" sizes. These illustrations show that Hassall—a specialty supplier—can show you substantial savings, better deliveries and no-charge assistance at all times.

Proof? Send us your specifications or write for catalog.

John Hassall, Inc., P. O. Box 2197 Westbury, Long Island, New York.

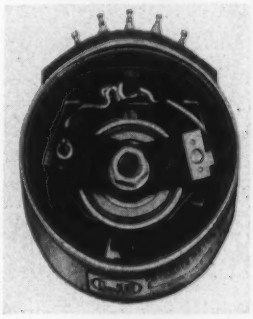
HASSALL

SINCE 1850

NAILS, RIVETS, SCREWS AND OTHER COLD-HEADED FASTENERS AND SPECIALTIES

—ITEM 217—

New Parts



stock; other linear and nonlinear functions can be supplied to meet special requirements. Power dissipation is 4 w and maximum temperature rise for continuous operation is 65 C. Linearity is ±0.5 per cent. Various tap arrangements are available in single or ganged assemblies. **Dejur-Amsco Corp.**, 45-01 Northern Blvd., Long Island City 1, N. Y.

—Circle ITEM 65

Nylon Balls

in 14 standard sizes

Typical applications of precision nylon balls include use in bearings, pumps, check valves and instruments. Quiet running and corrosion resisting, they are accurate

to 0.002-in. diameter and 0.001-in. sphericity. Stocked in 14 standard sizes from ⅛ to ¾-in. diameter the balls can be supplied in special sizes on order. **Industrial Tectonics Inc.**, 3684 Jackson Rd., Ann Arbor, Mich.

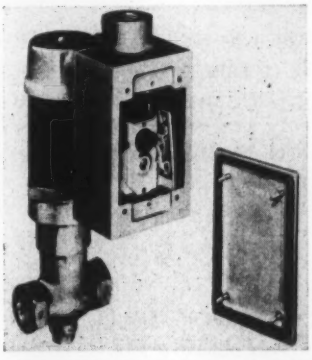
—Circle ITEM 66

Timer Valve

automatically controls flow

Available in a range of timing cycles, this timer valve automatically controls the flow of liquids, gases, or air. The unit incorporates a solenoid valve and a timer control

sealed in a water-tight housing. Flow can be turned on or off at any desired time, or controlled intermittently at any cyclic rate. The valve does not have to be reset



in repeat cycle operation. Operating on 110 or 220 v, 60 cycle ac, it can be supplied for 3/8-in. and larger pipes. **Automatic Controls Corp.**, 2390 Winewood, Ann Arbor, Mich.

—Circle ITEM 67

Teflon Tape

can be cemented to any surface

Treated Teflon tape, 0.005 to 0.060-in. thick, can be cemented with commercial adhesives to metal, glass, wood, plastic, or almost any other material. The tape can be used to insulate motor windings, to provide low-friction facings for guides, and to cover metals that are exposed to corrosive substances. When treated for adhesion on both sides, it can be laminated with a rigid dielectric for printed-circuit production. Widths to 12 in. can be supplied in continuous rolls. Sheets 1/32 and 1/16-in. thick are available in 24 x 24 in. and 48 x 48 in. sizes, respectively. **United States Gasket Co.**, 602 N. 10th St., Camden 1, N. J.

—Circle ITEM 68

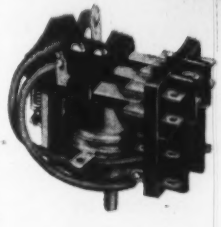
Linear Potentiometer

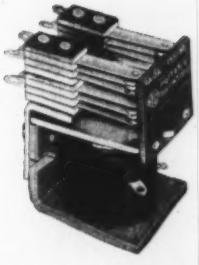
has 0.0008-in. resolution

Resistance values to 60,000 ohms per inch and total travels to six inches are available in line of miniaturized linear potentiometers. Resolution with single-turn taps is as low as 0.0008-in. Low noise is

LOW COST—HIGH QUALITY

Relays-a-Plenty





Potter & Brumfield, with its many years of Engineering and Production experience, builds relays to all quality levels.

Relays from the most exacting to the simplest in operating specifications are readily available at P&B.

Small or Large quantity orders receive the same careful attention by the people that have the "Know How."

Let Potter and Brumfield engineers become part of your design group in selecting the correct type of relay to meet all requirements.

For quick delivery over 350 different standard relays stocked by 500 Franchised Electronic Parts Distributors throughout the United States and Canada.

Send your specifications for samples and quotations.

Potter & Brumfield
PRINCETON, INDIANA inc.
SUBSIDIARY OF AMERICAN MACHINE AND FOUNDRY COMPANY

—ITEM 218—

need a finish
that blocks corrosion by itself—or under paint?

specify IRIDITE

You can solve any problem of non-ferrous finishing . . . maximum corrosion protection . . . sparkling clear or colored decorative finishes, firm and lasting base for paint . . . with these two words—"specify Iridite". For example—

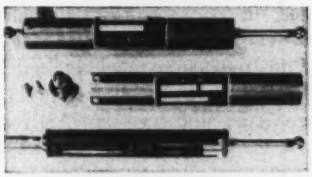
- **ON ZINC AND CADMIUM** you can get highly corrosion resistant finishes to meet any military or civilian specifications and ranging in appearance from olive drab through sparkling bright and dyed colors.
- **ON COPPER . . .** Iridite brightens copper, keeps it tarnish-free; also lets you drastically cut the cost of copper-chrome plating by reducing the need for buffing.
- **ON ALUMINUM** Iridite gives you a choice of natural aluminum, a golden yellow or dye colored finishes. No special racks. No high temperatures. No long immersion. Process in bulk.
- **ON MAGNESIUM** Iridite provides a highly protective film in deepening shades of brown. No boiling, elaborate cleaning or long immersions.

AND IRIDITE IS EASY TO APPLY. Goes on at room temperature by dip, brush or spray. No electrolysis. No special equipment. No exhausts. No specially trained operators. Single dip for basic coatings. Double dip for dye colors. The protective Iridite coating is not a superimposed film, cannot flake, chip or peel.

WANT TO KNOW MORE? We'll gladly treat samples or send you complete data. Write direct or call in your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified telephone book.

ALLIED RESEARCH PRODUCTS
INCORPORATED
4004-06 E. MONUMENT STREET • BALTIMORE 5, MD

New Parts



provided by use of dual wipers on each resistance element. Case is ½-in. OD, and is O-ring sealed to comply with environmental specifications of MIL-E-5272A. **General Components Co.**, 801 Eighth St. S. E., Minneapolis 14, Minn.

—Circle ITEM 69

Speed Reducer

has five ratio steps from 2.5 to 50:1

Model 100 BB gear reduction unit can be adjusted while running through five speed-ratio steps from 2.5 to 50:1. In addition to ratio points, the unit has a neutral station, eliminating the need for a clutch. All shafts are ball-bearing supported, and precision gears are

employed to minimize friction and backlash in servo-loop applications. Alternate model 105 DR can be supplied for applications where backlash is not of critical importance. Dimensions of the cast-aluminum housing are 3 in. height and 3⅞ in. length. Mounting is facilitated by T-slots and captive nuts in the base. **Haxton Gear Co.**, 7-11 Main St., East Rockaway, N. Y.

—Circle ITEM 70

Hose Fittings

are installed without stripping hose cover

Precision machined for high tensile steel, these reusable hose fit-

(*Continued on Page* 142)

This Space Saving Drive Solves Difficult Design Problems . . New R/M *Poly-V® Drive*

Could greater power capacity in less drive space mean an improvement in your equipment drive design? It can be done with R/M Patented Poly-V* Drive . . . R/M's totally new concept in heavy-duty power transmission! Actual installations have proved that this belt drive can deliver up to 50% *more* power in the same space as ordinary multiple-belt drives . . . or *equal* power in as little as 2/3 the space!

The unusual space-saving advantages of R/M Poly-V Drive are the result of over 5 years development by R/M engineers. Employing a single, endless parallel V-ribbed belt running on sheaves designed to mate precisely with the belt ribs, gives Poly-V Drive the strength and simplicity of flat belts *plus* the high V-groove grip of V-belts. It means you get twice the tractive surface of multiple V-belts in the same drive width . . . twice the power capacity . . . "More Use per Dollar".

OTHER IMPORTANT ADVANTAGES INCLUDE:

- Single Unit Design — Eliminates Belt Matching Problems
- More Uniform Tension — Prolongs Belt and Sheave Life
- Two Belt Cross Sections — Meet Every Heavy Duty Power Transmission Requirement
- Oil Proof, Non Spark, Heat Resistant

Investigate R/M Poly-V Drive for the improved design of both new and existing equipment. R/M engineers will gladly work with you on power transmission drive problems. Contact an R/M representative.

CONDOR V-BELTS • R/M SUPER-POWER V-BELTS

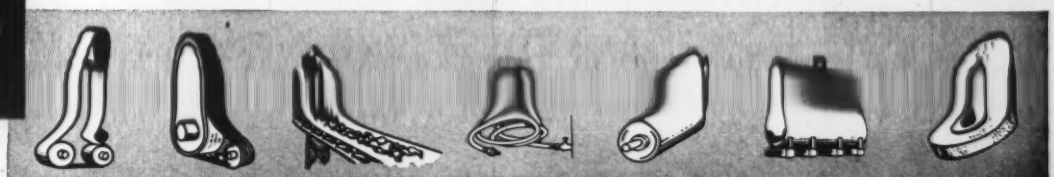
Write for Bulletin #6868 on the complete line of Condor V-Belts for regular service on conventional V-belt drives. Also write for Bulletin #6628 on R/M Super-Power V-Belts with 40% more Horsepower capacity where needed.

*Poly-V is a registered Raybestos-Manhattan Trademark

RM 627

MANHATTAN RUBBER DIVISION — PASSAIC, NEW JERSEY

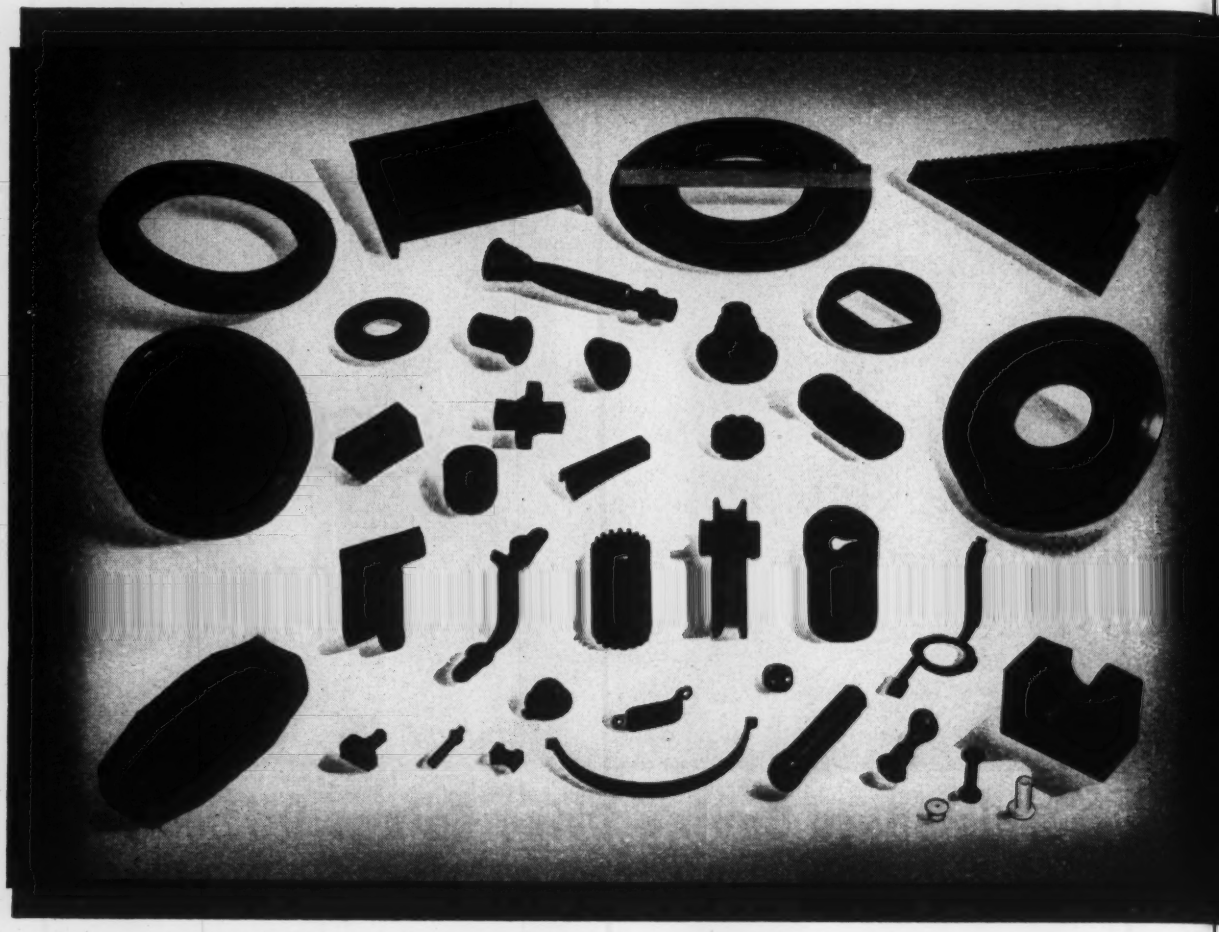
RAYBESTOS-MANHATTAN, INC.



Other R/M products include: Industrial Rubber • Fan Belts • Radiator Hose • Brake Linings • Brake Blocks • Clutch Facings • Asbestos Textiles • Packings • Engineered Plastic, and Sintered Metal Products • Laundry Pads and Covers • Bowling Balls

—ITEM 220—

CALL ON R/M ENGINEERING SERVICE



PRECISION MOLDED PARTS — RUBBER • SILICONE

For the *correct* precision-molded part for your new product, or to improve an existing one, call on R/M. Molded parts in natural or oil-proof synthetic rubber, silicone and nylon are custom-engineered to your most exacting specifications. High standards of precision, and modern facilities for manufacturing under exacting quality control assure longer, trouble-free service under extreme temperature, atmospheric, or other severe operating conditions. Perhaps molded parts of nylon or silicone may reduce production costs and give better service than the material you are currently using. R/M engineers will advise you. They are specialists in the application of molded parts and components . . . ready to assist you in determining the best design and material to improve product performance and prolong product life, or reduce cost.

R/M engineering and craftsmanship are backed by more than 60 year's experience in the manufacture of molded and industrial rubber products. Also, where your need calls for cut and extruded parts, R/M can custom-produce them to your special order.

Advantages of light, durable R/M Custom Molded Nylon Parts are detailed in a helpful, new illustrated booklet available on request. An R/M "Exclusive Features" book describes engineering advances in rubber hose, transmission and conveyor belts, V-Belts and patented R/M Poly-V® Drive, entirely new concept in heavy duty power transmission. Whatever your requirements, you can depend on R/M molded parts and industrial rubber products for solving your problems and reducing development time and costs. Let R/M specialists work with you on your next design.

For booklet shown, or other data, write, phone or wire:

MANHATTAN RUBBER DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
GRegory 3-2000

R/M

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METALS, ENGINEERED PLASTICS

Brake Blocks, Linings and Clutch Facings | Fan Belts and Radiator Hose | Mechanical Packings and Gaskets | Abrasive and Diamond Wheels | Industrial Drive Belts | Industrial and Automotive Hose

FOR HELP IN SOLVING YOUR PROBLEMS

FRICTION MATERIALS

Unlike other manufacturers, R/M works with *all* kinds of friction materials, from asbestos to sintered metals. This means that when you consult an R/M engineer you can be sure of completely unbiased advice on which materials are best for your application.

Raybestos-Manhattan has been the world's largest maker of friction materials for over 50 years. Whatever your brake or clutch requirements, count on R/M experience, and R/M manufacturing and testing facilities, for a friction material exactly suited to your needs.

Write for your copy of R/M Bulletin No. 500. It's loaded with practical design and engineering data on all R/M friction materials.

EQUIPMENT SALES DIVISION
Raybestos-Manhattan, Inc.
6010 Northwest Highway
Chicago 31, Ill.
ROdney 3-2400

PACKINGS, GASKETS ASBESTOS TEXTILES and "TEFLON"* PRODUCTS

Top-flight design engineering combined with superior molding techniques make R/M Vee-Flex Rings and R/M Fabric Piston Cups ideal for hydraulic and pneumatic applications. Together they do an outstanding job of lengthening equipment life and lowering maintenance costs. If you have a packing problem, call on R/M's specialized packing engineering service. R/M makes a complete line of mechanical packings—including Vee-Square, Universal Plastic, and "versi-pak."® It can also meet your requirements for asbestos textiles and "Teflon" products.

**Du Pont trade mark*

For booklet shown, or other data, write, phone or wire:

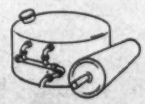
PACKING DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
GRegory 3-2000

ASBESTOS TEXTILE DIVISION
Raybestos-Manhattan, Inc.
Manheim, Pa.
Manheim 5-2211

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • No. Charleston, S.C. • Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Conveyor Belts



Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

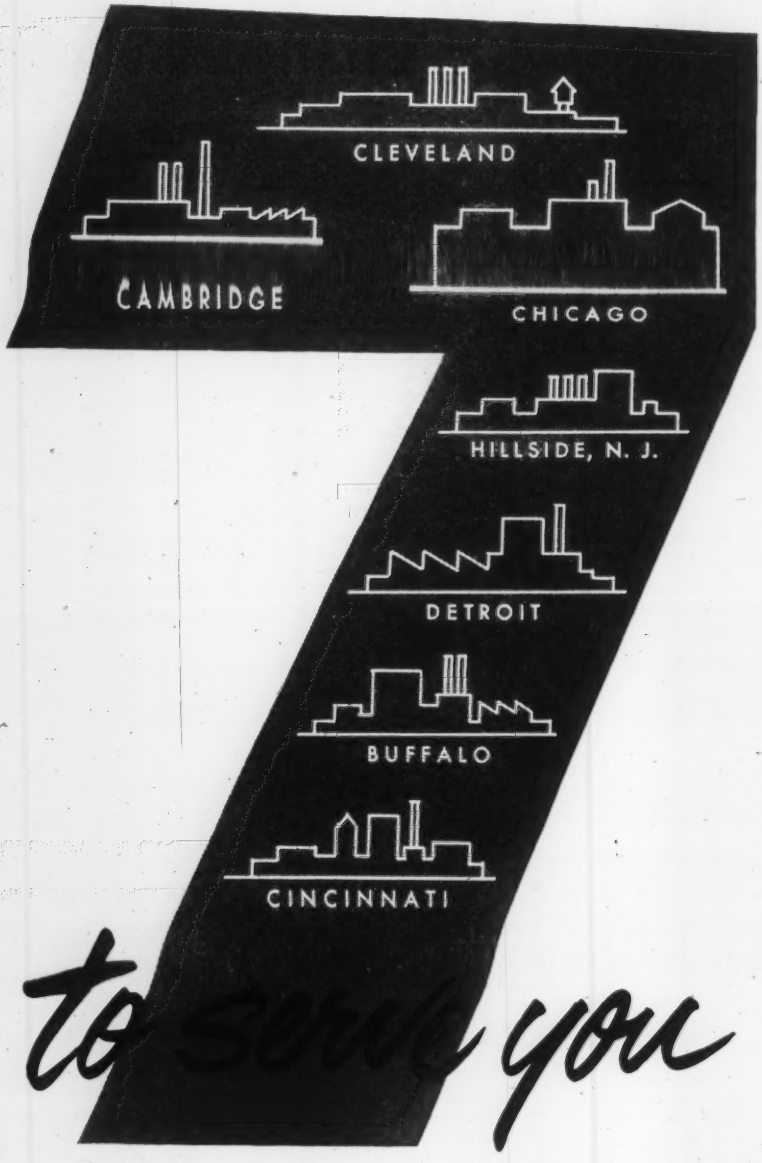
Asbestos Textiles

Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

R M

—ITEM 221—
For More Information Circle Item Number on Yellow Card—page 19



A call to any one of our seven warehouses will get you speedy service on your order . . . whether it's for *alloy steel bars, billets or forgings,* in any size, shape or treatment you need.

All seven warehouses are located in principal industrial areas. Each is modern and well-stocked, and staffed by expert metallurgists.

Call now if you need our own HY-TEN steels – "the standard steels of tomorrow", or standard AISI or SAE grades.

Or write for *free* copies of Wheelock, Lovejoy Data Sheets. They contain complete technical information on grades, applications, physical properties, tests, heat treating, etc.

In Canada: Sanderson-Newbould, Ltd., Montreal and Toronto

WHEELOCK, LOVEJOY & COMPANY, INC.

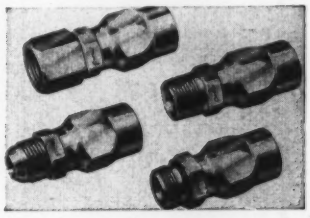
133 Sidney Street, Cambridge 39, Massachusetts

—ITEM 222—

New Parts

(*Continued from Page* 138)

tings are installed without stripping the rubber cover from wire-braid hose. The fittings consist of a socket and a nipple. Make-up of hydraulic assemblies is done in two steps: first, the hose is turned counterclockwise into the socket.



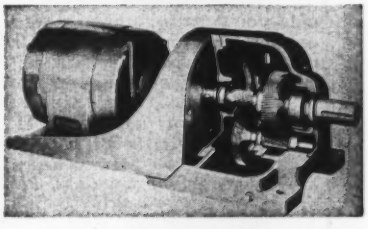
then the nipple is screwed clockwise into hose and socket. Pressure limit of the assembly is greater than the hose bursting pressure. Fittings are manufactured with four connecting ends: tapered male pipe thread, straight thread with O-ring seal, J.I.C. 37-deg flare nose for tube connection, and swivel nut for connection to any Triple-Lok adapter. Fittings are available for ¼, ⅜, and ½-in. ID hose. **Parker Appliance Co.,** Tube & Hose Fitting Div., 17325 Euclid Ave., Cleveland 12, O.

—Circle ITEM 71

Motor-Gear Assembly

with double or triple-

reduction stages



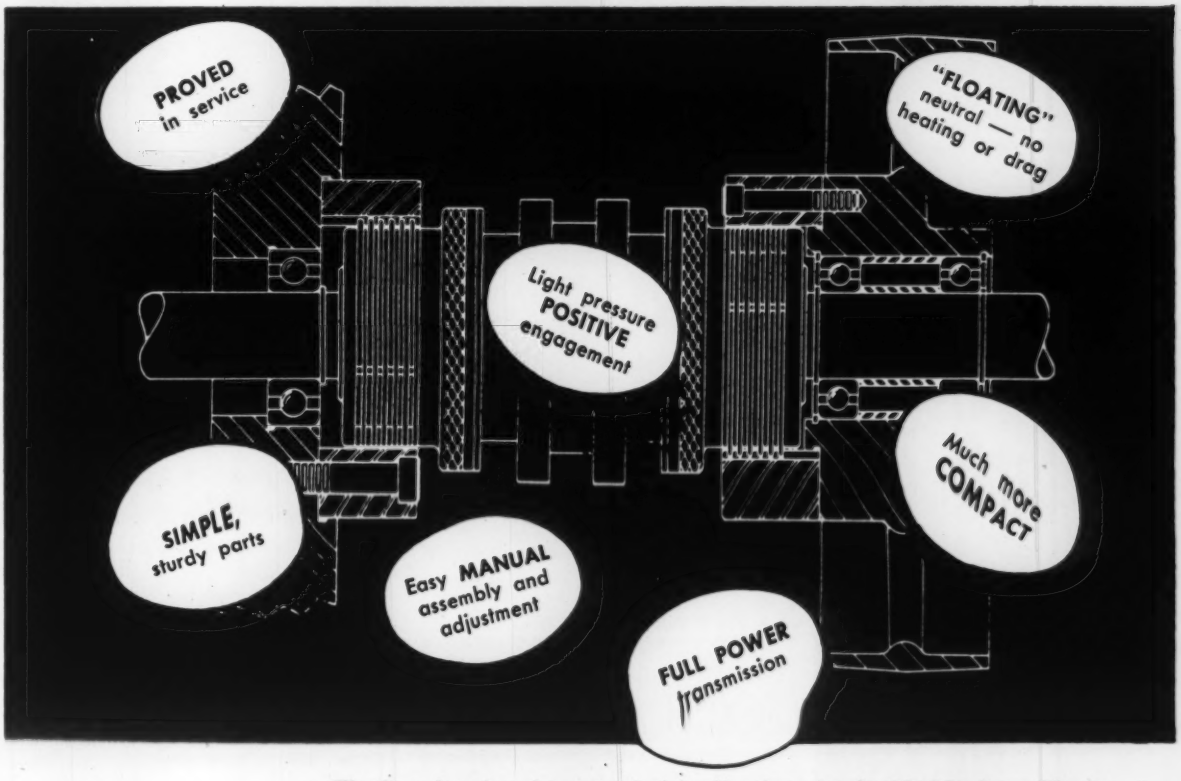
Designed for heavy-duty service. Motogear units are available in type DB, with double-reduction ratios from 6.2:1 through 38.4:1, and in type TB, with triple-reduction ratios from 47.1:1 through 292:1. Maximum power ratings of DB and TB models are 60 and 20 hp, respectively. Rigidity of the high-speed shaft and pinion is provided by straddle-mounting the pinion, which permits the unit to withstand shock, rapid reversal, and heavy loads without shaft deflec-

ASSURE YOUR PRODUCT THE PROVED SUPERIORITY OF A

MAXITORQ

floating disc

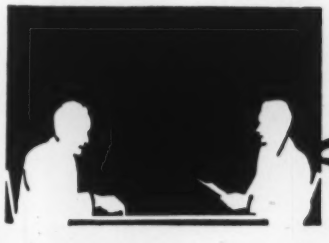
CLUTCH


PROVED in service
"FLOATING" neutral — no heating or drag
Light pressure POSITIVE engagement
Much more COMPACT
SIMPLE, sturdy parts
Easy MANUAL assembly and adjustment
FULL POWER transmission

The line drawing shows typical application of a double Maxitorq Floating Disc Clutch, arranged for both drive and brake, with ring-type driving cups.

Such installations have a well-proved record of efficiency and freedom from maintenance. Drive and brake engagement and disengagement are smooth and positive . . . without drag or heating . . . because exclusive MAXITORQ design assures that discs ride free in neutral.

MAXITORQ Floating Disc Clutches are available in a wide range of sizes and types . . . single, double, overload release . . . to meet specific installation demands. Our engineering department also stands ready to help you solve special drive problems. Write or phone Dept. MD-3. The Carlyle Johnson Machine Company, Manchester, Conn.



Let's talk **MAXITORQ**

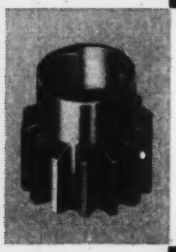
8CJ88

a new expanded field of

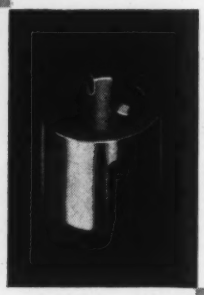
BEARING DESIGN and APPLICATION

The inauguration of Bunting's new facility for engineering and manufacturing bearings and parts of Sintered Powdered Metals opens a wide new area of opportunity to all mechanical industry.

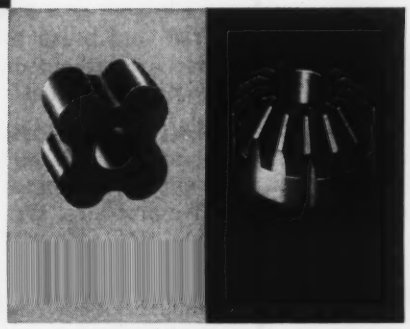
Sintered Powdered Metal Bearings and parts offer real economies in design. Bunting Engineering and manufacturing skill and traditional technical responsibility assure your most advantageous use of this material.



A competent group of Bunting Sales Engineers in the field and a soundly established Product Engineering Department put at your command, comprehensive data and facts based on wide experience in the designing and use of Cast Bronze and Sintered Powdered Metal Bearings and parts.



Write to our Product Engineering Department in Toledo, or consult our nearest Sales Engineer.



Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

—ITEM 224—

New Parts

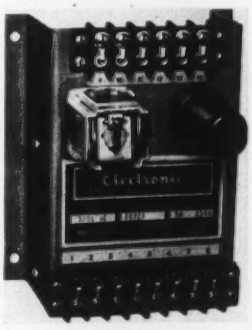
tion. The Motogear is rated in accordance with AGMA standards. **Link-Belt Co.**, 307 N. Michigan Ave., Chicago 1, Ill.

—Circle ITEM 72

Liquid Level Control

uses no moving parts in contact with liquid

Liquid levels are held within narrow limits by this MEK-3001 electronic control without use of floats



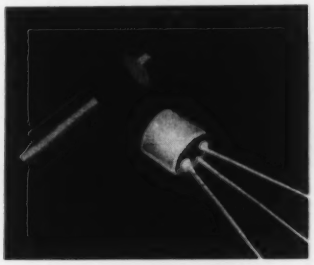
or other moving parts. In pump-up or pump-down service, the control is actuated when a low-voltage probe contacts the liquid. Adjustable sensitivity permits the unit to monitor any fluid with resistivity in the range 0 to 2-million ohms per cubic centimeter. Shock hazard is eliminated since the probe operates at 12½ v maximum and is transformer-isolated from the 115/230 v ac supply. Relay rating is 5 amp, 115 v, noninductive. The control enclosure meets NEMA requirements and can be supplied in 316 stainless steel. **Machinery Electrification Inc.**, Northboro, Mass.

—Circle ITEM 73

Subminiature Rectifier

provides direct current for relay operation

Measuring 0.38-in. OD and 0.38-in. long, this subminiature selenium

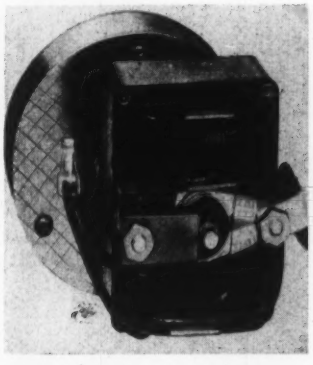


rectifier can be used to provide direct current for energizing relay coils. Rated at 66 v maximum ac input, it delivers 22 ma dc as center-tap rectifier or 11 ma as half-wave unit. Allowable ambient temperature range is −50 C to 100 C. Designated type 60-9267, the rectifier is potted in epoxy resin to permit operation under severe environmental conditions, such as moisture, fungus, or corrosive vapors. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif.

—Circle ITEM 74

Brake Motor

can be stopped within 10-deg rotation



Fractional horsepower induction motor has spring-type brake that stops shaft rotation within 10 deg for final shaft speeds below 50 rpm. Designated series 500, the motor can be supplied with gear reductions from 4.5:1 to 2,592,000:1 and in synchronous or nonsynchronous models. Torques up to 240 oz-in. are available, and units can be ganged for heavy-duty applications. **Gleason-Avery Inc.**, 29 Clark St., Auburn 2, N. Y.

—Circle ITEM 75

Vacuum Control Units

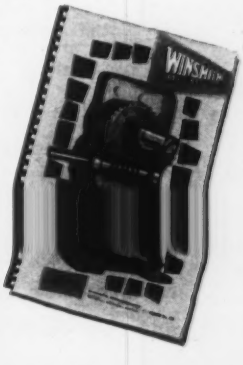
for regulating or limiting vacuum

Vacuum regulator, designated type D-51, maintains a lower vacuum at the valve inlet than exists at the high-vacuum source connection. Change in controlled vacuum produces correcting movement in the full-floating valve mechanism. Vacuum breaker, type D-52, maintains

(*Continued on Page* 148)

Something NEW has been added to Winsmith speed reducers...it's the new "C" Series with five new features that make every reducer in the line your best dollar for dollar buy. Both input and output shafts are larger and stronger, larger tapered roller bearings are used throughout, contoured fins at base give secure, vibrationless mounting and housings are designed for greater heat radiating capacity. *Net result?* Greater performance, greater stamina, greater dependability.

The "C" Series is comprised of 108 models in both single and double reduction units—there is a unit to meet every speed reducer need—*with greater value for your horsepower dollar.*



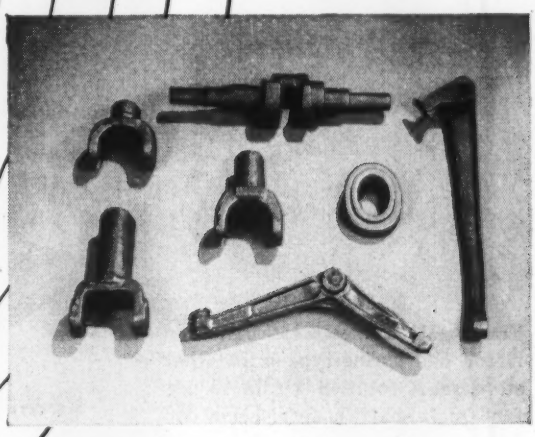
WINSMITH SPEED REDUCERS

GET THE FACTS:
on the complete "C" Series...write for Winsmith's new catalog. Contains complete engineering selection information for each reducer described.

WINSMITH, INC. 16 Elton Street, Springville, (Erie County), N. Y.

—ITEM 225—

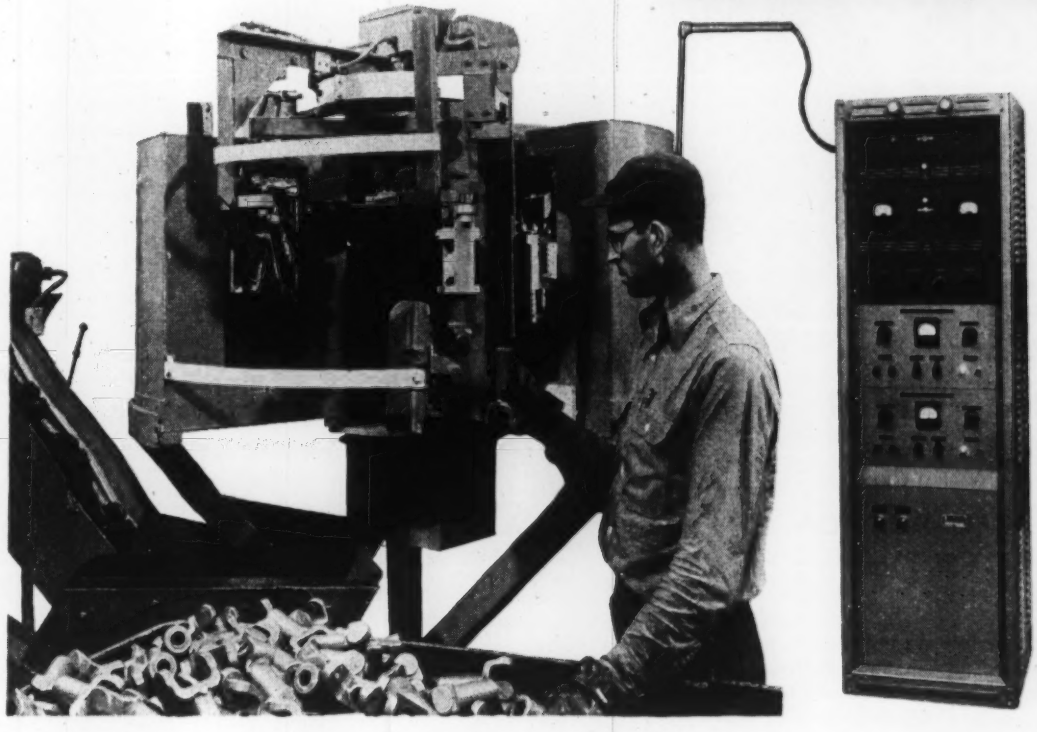
ELECTRONIC EAR AT CENTRAL FOUNDRY CAN **HEAR** QUALITY OF CASTINGS



new sonic testing mechanism retains or rejects a casting depending on its sound waves

In their search for a positive method of inspecting critical high-stressed castings, Central Foundry engineers developed a machine (Pat. Applied For) based on a fact known to foundrymen for generations—when a casting is struck it will not give off a clear, ringing tone if it is faulty. Central Foundry's electronic listening unit automatically distinguishes between the vibrations of good and faulty castings, and sorts them accordingly. This sonic tester is considerably faster and more accurate than visual inspection, and is suited to high production operation. And, most important of all, it eliminates the factor of human error. The sonic unit consists of a fixture for the castings, a steel ball mallet, a crystal microphone pick-up, a pre-amplifier, an oscillograph, and an audio oscillator which registers the reading and actuates the mechanisms for handling the castings and discharging them automatically onto good or reject conveyors. During production runs with the sonic tester, several things have been

From the laboratory to a completed high production casting testing machine is another achievement of the engineering staff of Central Foundry Division.



learned: • Not only cracks, but flaws such as cold shuts, are detected. • A good casting, if quenched but not drawn, will be rejected by a sonic tester which has been set for drawn castings. • A slight change in the pattern will cause castings to be rejected till the change is corrected. It is easy to see how a much higher quality casting can be assured when production runs are inspected so accurately. Sonic testing is especially important for the close-tolerance shell castings on highly-stressed parts now being produced in large quantities by Central Foundry Division.

Thus, through its constantly advancing research, and the quick, large-scale application of that research to day-to-day operations, Central Foundry Division offers another valuable service to its customers. For information on our shell casting or sand casting of grey iron, malleable iron, or ArmaSteel, write for descriptive literature or a consultation with our experienced engineers.

62

CENTRAL FOUNDRY DIVISION · GENERAL MOTORS CORPORATION

CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 14

We Cracked the TIME BARRIER!

with DPS

MODERN POWER METHODS!

No need for PRODUCTION DRAG on these assembling and feeding jobs!

When you can combine greatly stepped-up output with reduced costs, quality control and uniform results, it adds up to benefits you can't afford to ignore. Advantages that are emphasized by the use of

DPS POWER SCREWDRIVERS and SELECTIVE PARTS FEEDERS

And remember, D.P.S. specially trained engineers are ready to tackle your problem and come up with the right answer.

5 MODELS BENCH AND PEDESTAL TYPES

3 STYLES 10 MODELS

Shown are two products from our expanded up-to-the-minute line. Get the story. Write for catalog and full details.

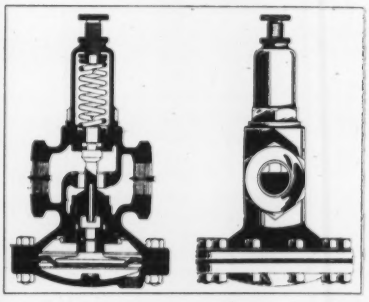
COME AND SEE US
Booth 571 A.S.T.E. Industrial Exposition

DETROIT POWER SCREWDRIVER CO.

2801-A W. FORT ST. DETROIT 16, MICH.

—ITEM 227—
For More Information Circle Item Number on Yellow Card—page 19

(Continued from Page 145)



a predetermined vacuum by automatic admission of atmospheric air or other suitable fluids. The valve inlet in D-52 is exposed to the atmosphere and the outlet is connected to the equipment in which vacuum is to be limited. Designed for use with noncorrosive liquids and gases, these units are supplied for pipe sizes from ½ to 1¼ in. **A. W. Cash Valve Mfg. Corp.**, 666 Wabash Ave., Decatur, Ill.

—Circle ITEM 76

Transistorized Power Supply

is compact and lightweight

Suitable for cathode-ray tube and similar high-voltage circuitry, transistorized power supply series provides up to 16,000-v dc output

on 3-v dc input. Weighing 6 oz and occupying 4 cu in., the unit withstands a 20,000-g acceleration. Containers are rectangular or circular, or can be custom-made to specifications. **Universal Atomics Corp.**, 19 E. 48th St., New York 17, N. Y.

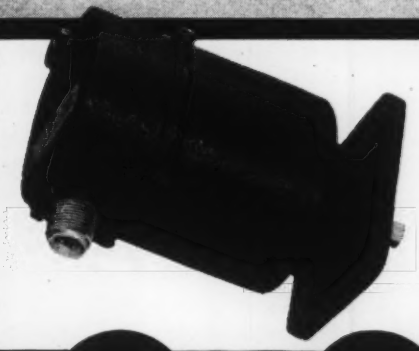
—Circle ITEM 77

Snap-Action Switch

has simple design

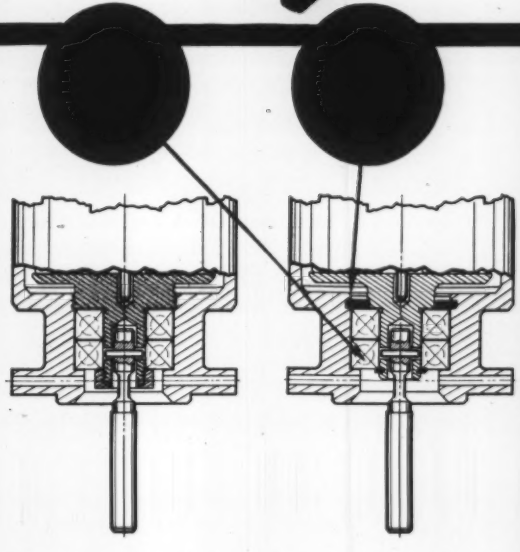
Designed as low-cost unit, this snap-action switch is sealed against water, dirt, chemicals, and explo-

10 Waldes Truarc rings speed assembly— Eliminate parts and machining in precision control



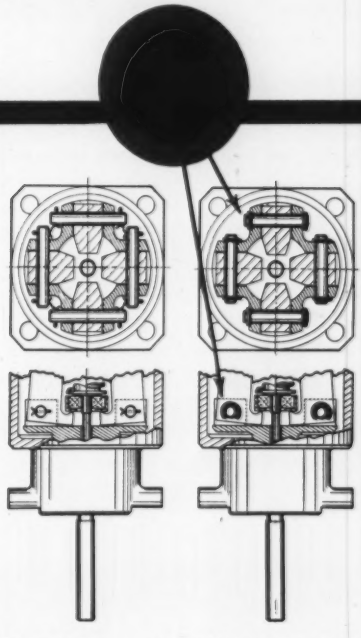
Kahn Rotary Speed Control

Kahn and Company, Inc., of Hartford, Conn., use a total of 10 Waldes Truarc Retaining Rings in this new mechanical-electric translator for automatic control of rotary speed. Truarc rings act as positioners and retainers to eliminate parts, simplify operations, save labor, and speed assembly.



Rotor Installation. In the old way, ball bearing was retained by a threaded shoulder and threaded bearing cup retainer.

New way, using two Truarc Rings (Series 5100 and 5000) eliminates 4 threading operations, bearing shoulder and threaded bearing cup. Assembly is quicker and easier, two ounces lighter.



Flyweight Assembly. Formerly, 2 holes had to be drilled in each of the 4 pivots, and 8 cotter pins were required.

The new way, using 8 Truarc E-Rings (Series 5133), replaces holes with grooves, reduces pivot size, leaves no projecting parts. Rings snap into place, speed assembly time by three minutes per unit.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

For precision internal grooving and undercutting ... Waldes Truarc Grooving Tool!

Send for new catalog supplement

WALDES TRUARC® RETAINING RINGS

Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N. Y.

Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.

(Please print)

Name.....

Title.....

Company.....

Business Address.....

City.....*Zone*.....*State*.....

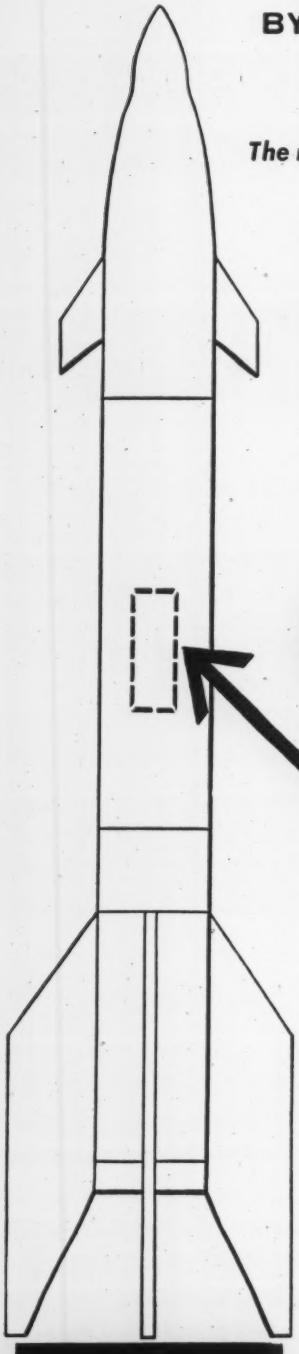
MC038

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

—ITEM 228—

For More Information Circle Item Number on Yellow Card—page 19

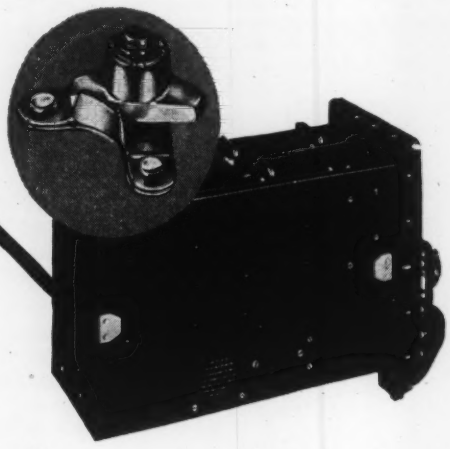
NEW PANELOC
ROTARY LATCH ADVANTAGES LISTED
BY BELL *Aircraft* CORPORATION



The next 135 words of this advertisement taken from Bell Engineers' letters

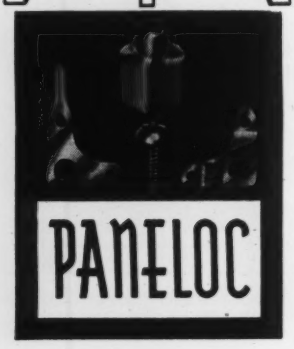
S. W. Esmond, Product Engineer:

- Electronic equipment shown was designed to use the PANELOC Rotary Latch at a great saving in space and weight, so vital to the aircraft engineer.
- Rotary Latch assembles to door or panel itself—no stud-to-receptacle line-up problem.
- Tests show no sheet separation—fastener locks with the effect of a nut and bolt assembly.
- Vibration tests also had no effect on the Rotary Latch.



F. P. Bassett, Project Engineer:

- Rotary Latch selected for use on cowl access doors on Bell's latest vertical-rising (VTOL) aircraft.
- The new PANELOC Rotary Latch is excellent for hinged doors and applications where maximum access and opening are important design considerations.
- Its simplicity, vibration resistance, ease of installation and cost are other factors that resulted in Bell's adoption of this new fastener.
- Now in use on fixed-wing aircraft, helicopters, missiles, electronic components.



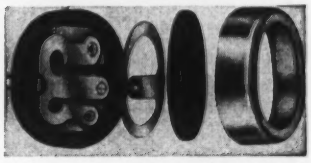
Write for catalog and price list for your file

A PRODUCT OF **SCOVILL**

Scovill Manufacturing Company, Aircraft Fastener Div.
50 Mill Street, Waterbury 20, Connecticut

—ITEM 229—

New Parts



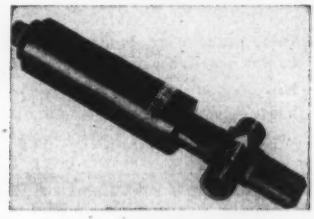
sive gases. Wide contact gap of the W-type contact element ensures positive snap action and resistance to shock and vibration. Current rating is 15 amp inductive and 10 amp resistive load at 6 v, dc. Operating force is 6 oz. In addition to the basic switch, roller-actuated and toggle-actuated models can be furnished. **Electra Mfg. Co.,** 4051 Broadway, Kansas City, Mo.

—Circle ITEM 78

Motorized Hydraulic Valve

has flow range from 0.00006 to 50 gallons per minute

Designed for precision flow control, this hydraulic valve uses a miniature 28 v dc motor to position the valve spool through an integral gear train. Motor and gear-reduction combinations can be selected to give full-stroke times from several seconds to a minute. Flow



range with 60 SSU oil is 0.00006 to 50 gpm. Control boxes are provided to satisfy the particular control mode desired, and 115-v, 60-cycle, or 400-cycle inputs can be specified. **United Hydraulics Inc.,** 110 Terrel Court, Dayton 7, O.

—Circle ITEM 79

Dual Lamp Indicator

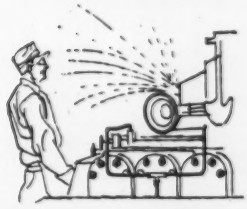
with neon or incandescent bulbs

Four different conditions can be displayed by model 1F miniature indicator, which contains two independently wired bulbs. Lenses can be provided in several colors, and replaceable plug-in bulb assembly contains either neon or incandescent bulbs. The indicator

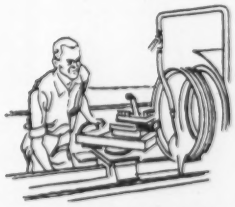
Let American Welding handle the job!

The next time design requires a circular weldment, or you think fabrication of a complicated weldment might be the best solution, give us a call. Our Industrial Products Division stands ready to assist manufacturers with problems involving fusion or resistance welding of all types of metals. In addition, we are actually a complete manufacturing plant with the "know-how," the manpower, and the facilities to handle the operations required to produce finished welded components of complex design or assembly. Send today for our new 24-page catalog describing American Welding facilities that are available. Let us demonstrate what American Welding can do for you.

WELDING



FABRICATING



MACHINING

AMERICAN WELDING

THE AMERICAN WELDING & MANUFACTURING CO.
130 DIETZ ROAD • WARREN, OHIO

KEEPS "Monkey-Wrenches" OUT OF GEARS!

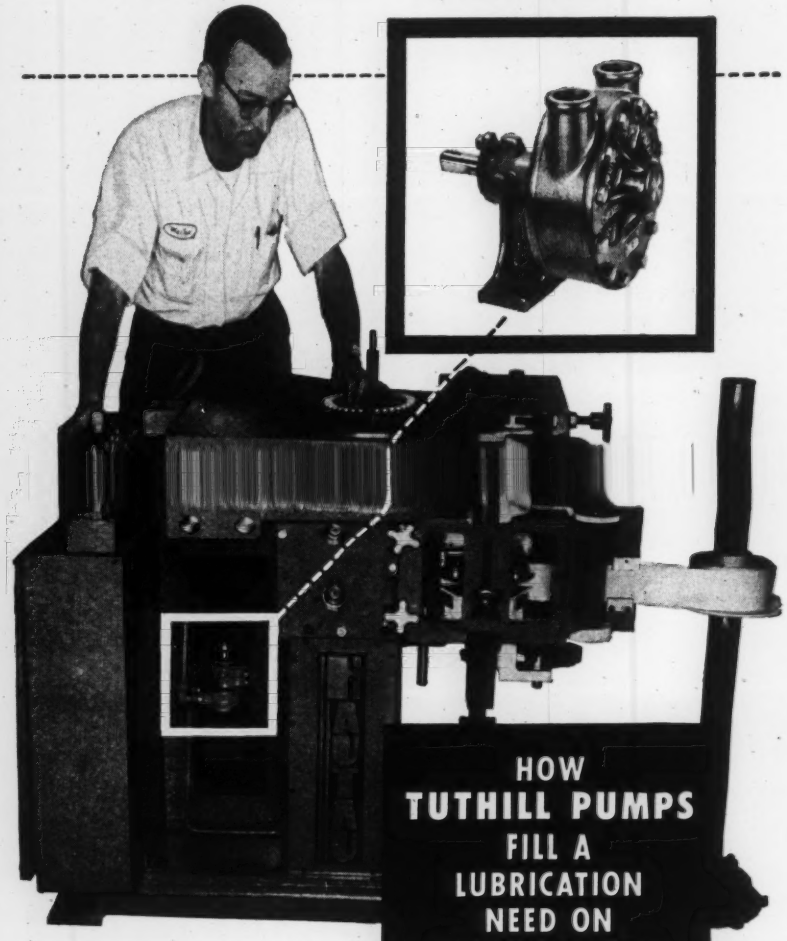


Photo of Automatic Stator Insulation Machine, courtesy Hautau Engineering Company, Ferndale, Michigan

HOW TUTHILL PUMPS FILL A LUBRICATION NEED ON MACHINES FOR AUTOMATION

In developing this machine that automatically forms and inserts insulation for the stators of electric motors, Hautau engineers required a dependable pump for lubricating the various operating gears and indexing mechanism. For this vital service they selected the Tuthill Model C internal-gear rotary pump.

The performance characteristics of this positive displacement pump make it ideal for pressure lubrication. It holds its prime. Instantly delivers the capacity needed. Operates quietly. And it is built for long, uninterrupted service. Tuthill specializes in building pumps for the purpose. Whether your production calls for standard pumping units or special pumps for engineered applications in lubrication, coolant, hydraulic or liquid transfer service, it will pay you to submit your specifications for recommendations.

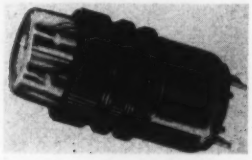
Write today for complete data on Tuthill Pumps for lubrication or other specific service.

TUTHILL PUMP COMPANY
Dependable Rotary Pumps . . . since 1927
939 East 95th Street, Chicago 19, Illinois

Canadian Affiliate: Ingersoll Machine & Tool Co., Ltd.
Ingersoll, Ontario, Canada

—ITEM 231—

New Parts



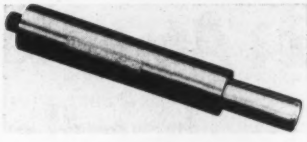
is 1.80 in. long and mounts in a 0.75-in. hole in panels up to 3/16-in. thick. The insulated case is black anodized aluminum. **Eldema Corp.**, 9844 Remer St., El Monte, Calif.

—Circle ITEM 80

Liquid Spring

develops wide range of spring forces

Measuring 7⅜ in. long by 1⅜ in. diameter, this liquid spring develops an 8000-lb spring force in a 1-in. stroke. Preload is 1300 lb, and shock absorbing action equals that of two automobile shock absorbers. Design of the spring permits development of spring forces as low as 600 lb without use of external levers. It is available in a range of forces and deflections. **Taylor Devices Inc.**, 188 Main St., North Tonawanda, N. Y.



—Circle ITEM 81

Automatic Lubricator

meters filtered oil at seven flow rates

Components of this automatic cyclic lubrication system are: a combination pump and reservoir (shown) which periodically feeds predetermined quantities of oil into the feed lines; a distribution system that carries oil to lubrication points; and metering units for filtering and measuring the oil at each point. Designed to provide automatic multipoint lubrication for high-speed packaging machinery and similar equipment, the device requires no separate power source since it is driven by the machinery it lubricates. Metering units at lubricated points are available in seven different flow rates

DU PONT ELASTOMERS

in Design

HYPALON® tank linings for strong oxidizing agents

Now a wide range of chemicals can be safely handled by storage tanks and shipping containers for long periods. The secret is a lining made of HYPALON, Du Pont's new synthetic rubber. Tank linings of HYPALON have extra-high resistance to chemicals—even the strongest oxidizing agents have little effect on linings of HYPALON.

But exceptional chemical resistance is just part of the story: HYPALON also withstands temperatures from 250°F. to 350°F. It is *completely unaffected* by ozone and can take prolonged exposure to weathering and sunlight without deteriorating.

TANK LINED with HYPALON for storage of calcium hypochlorite. HYPALON is applied by standard lining methods, adheres firmly.

HYPALON can provide extra-high durability to products exposed to severe service conditions; such as hose for handling strong acids and hot fluids; gaskets and packings in high-temperature service; protective coatings for metal and masonry; and many others. To become acquainted with Du Pont HYPALON—just clip and mail coupon.

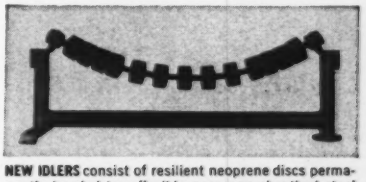
Flexible NEOPRENE idlers for conveyor belts outlast steel idlers better than 8 to 1

NEOPRENE IDLERS are still in service after two years. Accumulated sand previously fouled the steel idler bearings, stopped the idlers and damaged the belt. Average service was three months.

NEOPRENE resists abrasive action of sand, retains its flexibility

At one point in the production of castings at a magnesium foundry in the Midwest a conveyor belt carries molding sand from a chute up a 35° incline to another belt. Sand builds up under the belt. When the belt ran on steel idlers, sand fouled the bearings, jammed the idlers and damaged the belt. Average service life of the steel idlers was three months.

The manufacturer decided to install flexible idlers made of neoprene. The new idlers, developed by Joy Manufacturing Company, consist of neoprene discs permanently bonded to a flexible neoprene-sheathed steel cable and suspended from a single sealed bearing at each end. These end bearings are up out of the sand so spillage does not affect them. The discs supporting the belt, being flexible, conform to the shape of irregular loads, reducing loss of material through spillage. The idlers clean themselves because constant flexing forces the sand from between the rotating discs. Neoprene was the natural choice for this use because of its lasting resilience and resistance to the abrasive action of the sand. After two years—*more than eight times the service life of the steel idlers*—the neoprene idlers are still on the job.



NEW IDLERS consist of resilient neoprene discs permanently bonded to a flexible neoprene-sheathed steel cable which is suspended from a single sealed bearing at each end.

Specify neoprene in the rubber products you design. Of all general-purpose elastomers, only neoprene possesses a *balanced combination of properties*. For further information on designing new or improved products with neoprene clip and mail the coupon below.

DU PONT
REG. U. S. PAT. OFF.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Please send further literature and add my name to the mailing list for your free publications, the "Neoprene Notebook" and "Facts about HYPALON®," which show how the Du Pont elastomers are used in designing new products, improving old.

E. I. du Pont de Nemours & Co. (Inc.)
Elastomers Division, Dept. MD-3
Wilmington 98, Delaware

Name _____ **Position** _____

Firm _____

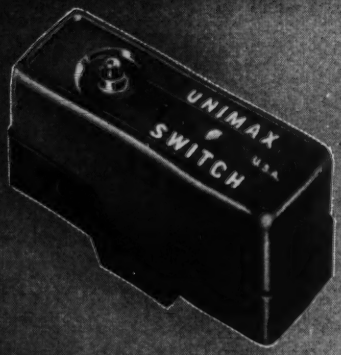
Address _____

City _____ **State** _____

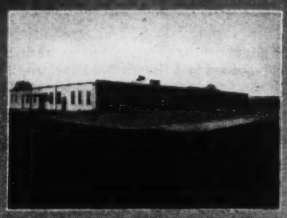
MILLIONS OF OPERATIONS

NEW

UNIMAX SWITCH



Gives MILLIONS of OPERATIONS



To meet accelerated demands for Unimax precision switches, we now occupy a new modern plant, fully air-conditioned, with filtered and electrostatically cleaned air precisely controlled as to temperature and humidity. Enlarged new manufacturing and laboratory facilities enable us to maintain even higher standards of performance.

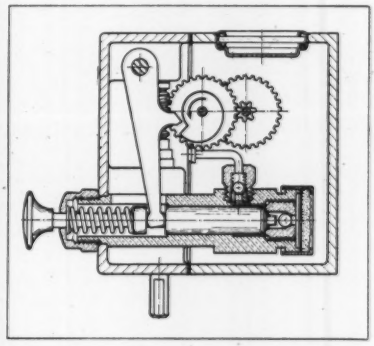
Series HB 20-ampere Miniature Snap-acting Switch

- HEAVY DUTY . . . 20 amp. 125/250/480 v.
  a-c ratings 1½ horsepower 250 volts; ¾ horsepower 125 volts
  d-c ratings 0.50 amperes 125 volts; 0.25 amperes 250 volts
- REPEAT ACCURACY . . . Consistent throughout switch life.
- WIDE VARIETY . . . of standard overtravel plungers and leaf actuators; special actuators can be furnished to your requirements.
- FREE CATALOG . . . gives details of entire Unimax Switch line. Write for your copy.

UNIMAX SWITCH
Division The W. L. Maxson Corporation
IVES ROAD, WALLINGFORD, CONNECTICUT

—ITEM 233—
For More Information Circle Item Number on Yellow Card—page 19

New Parts



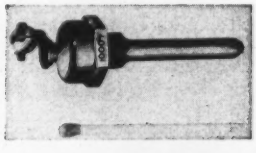
and incorporate filters and check valves to ensure clean, one-directional oil flow. Oil pressure in the distribution system is 40 psi. Reservoir capacity is 1 pint. **Bijur Lubricating Corp.**, 151 W. Passaic St., Rochelle Park, N. Y.

—Circle ITEM 82

Thermal Switch

rated from −20 to + 1000 F

Operating differential of this fast-acting thermal switch is ± 1 deg, and calibration temperature rating is −20 to + 1000 F. It will withstand momentary temperature overshoots to 2000 F and undershoots to −80 F. Weighing less



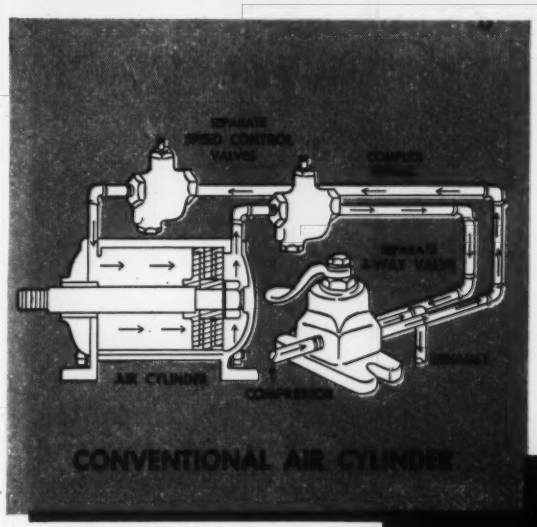
than 1 oz, the switch is corrosion resisting and is furnished with normally-open or normally-closed contacts. Electrical rating is 1.5 amp at 28 v dc, resistive loading. **Control Products Inc.**, 306 Sussex St., Harrison, N. J.

—Circle ITEM 83

Teflon Insulators

for feed-through or stand-off service

Self-sealing and self-fastening, Teflon feed-through and stand-off insulators are resistant to heat, pressure altitudes, humidity, and mechanical shock. Allowable temperature range is −110 to 500 F, pressure-altitude limit is 80,000 ft, and voltage breakdown at 160 F and 95 per cent humidity is 5000 v dc at



ONE LOOK

and you can see the

SAVINGS

THE COMPACT, STREAMLINED BELLOWS AIR MOTOR—

A complete work unit with built-in directional valve, speed control valves, and requiring but one air connection.

Design engineers looking for simplicity and economy in air circuit installations will find a quick answer in the two circuits sketched in this ad. One shows a conventional air circuit with separate air cylinder, separate speed control valves, separate directional valve and the piping required to install the circuit. The other shows the Bellows Air Motor—the complete air cylinder package—with directional valve and speed control valves built in, and its single air connection.

But simplification of design and installation problems is actually one of the less important advantages this compact power unit offers. The big advantages are precision control and improved performance. Response is lightning fast; action is smooth and positive. And coupled with improved performance is minimum maintenance —less time out for servicing.

The Bellows Air Motor offers you a choice of *built-in* directional valves: 8v or 110v electrical control, explosion-proof electrical control, manual control, or pilot valve control—in five bore sizes: 1″, 1¾″, 2½″, 3⅝″ and 4½″, and in any stroke length.

This new four-color, 24-page bulletin gives full technical data on Bellows Air Motors.

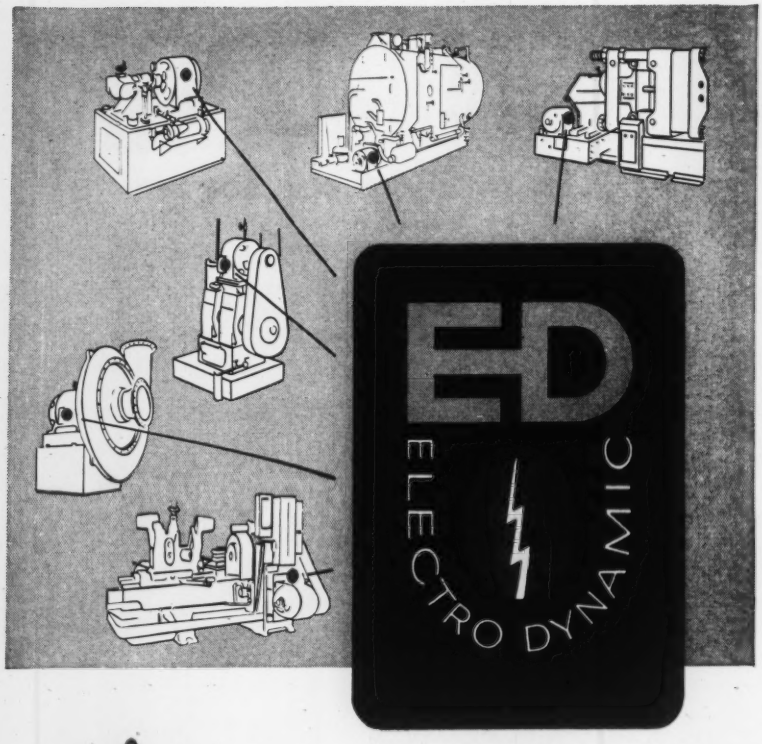
It is free on request. Ask for BM-25. Write Dept. MD-356, The Bellows Co., Akron 9, Ohio. In Canada, Bellows Pneumatic Devices of Canada, Ltd., Toronto.

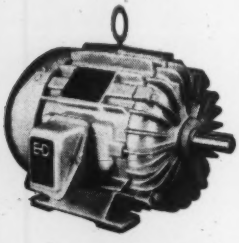
The Bellows Co.

AKRON 9, OHIO

1379A

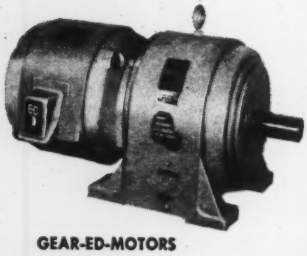
FIELD ENGINEER OFFICES IN EVERY INDUSTRIAL AREA IN THE UNITED STATES AND CANADA





STANDARD MOTORS

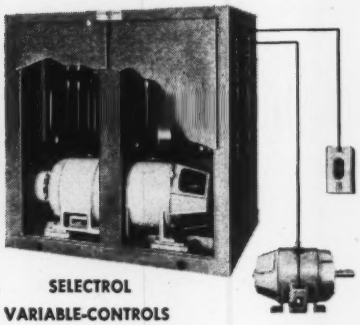
THIS EMBLEM IDENTIFIES EXTRA DEPENDABLE INDUSTRIAL MACHINERY



GEAR-ED-MOTORS

The red *power spot* on industrial machinery means "Powered by Electro Dynamic." Such machinery relies with confidence on the *extra dependability* of Electro Dynamic motors, the proven industrial motors which give industrial equipment *extra dependable* operation.

SELECTRON VARIABLE-CONTROLS



SELECTROL VARIABLE-CONTROLS

NEW...

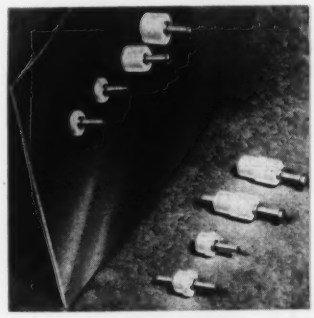
Write for Brochure 50 and literature on new E.D. motors and drives.

Electro Dynamic division of General Dynamics Corporation Bayonne, New Jersey

ELECTRO *xtra* **DYNAMIC** *ependable motors*

GD GENERAL DYNAMICS

New Parts



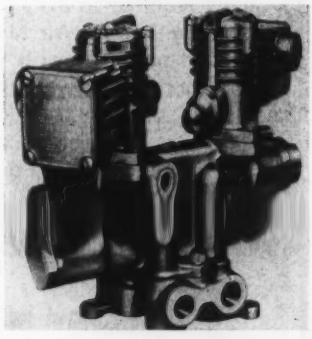
sea level. Solder terminals are gold-plated brass, and dielectric strength of Teflon bodies is 500 v per mil. Flashover voltages of S-11168 miniature and S-11148 subminiature stand-off insulators are 4000 and 500 v ac, respectively. Miniature feed-through insulator (S-11140) has flashover point of 3000 v; subminiature feed-through (S-11151) has 500 v flashover point. **Shamban Engineering Co.**, 11617 W. Jefferson Blvd., Culver City, Calif.

—Circle ITEM 84

Four-Way Valve

has 20-million cycle service life

This pilot-operated four-way valve operates on momentary electrical contact (10 amp max inrush) at rates up to 600 cycles per minute. Designated the double-solenoid Speed King, it has a Navy M bronze body and a hard chrome-plated valve stem to provide resistance to corrosion. No springs are employed



in the main valve, pilot plungers and valve stems being the only moving parts. Pilot solenoid coils are molded in epoxy resin and can be furnished for ac or dc operation at any voltage. The stainless-steel main valve stem floats on stationary O-ring packings to minimize friction and wear. Service life is at least 20-million cycles. Valves are available in ¼ to 1 in. pipe

When steel is 3 times stronger than iron . . .

Has two and one-half times the rigidity . . .

Yet costs a third as much per pound . . .

WHY

aren't more of your products designed for welded steel

FORMER CONSTRUCTION COSTS 85¢

WELDED STEEL DESIGN COSTS 65¢

A 23% reduction in cost . . . by a simple change in design. But that's not all. The welded steel design uses less material . . . but is stronger, more rugged.

Let Lincoln duplicate these savings and benefits on your products. Write us today.

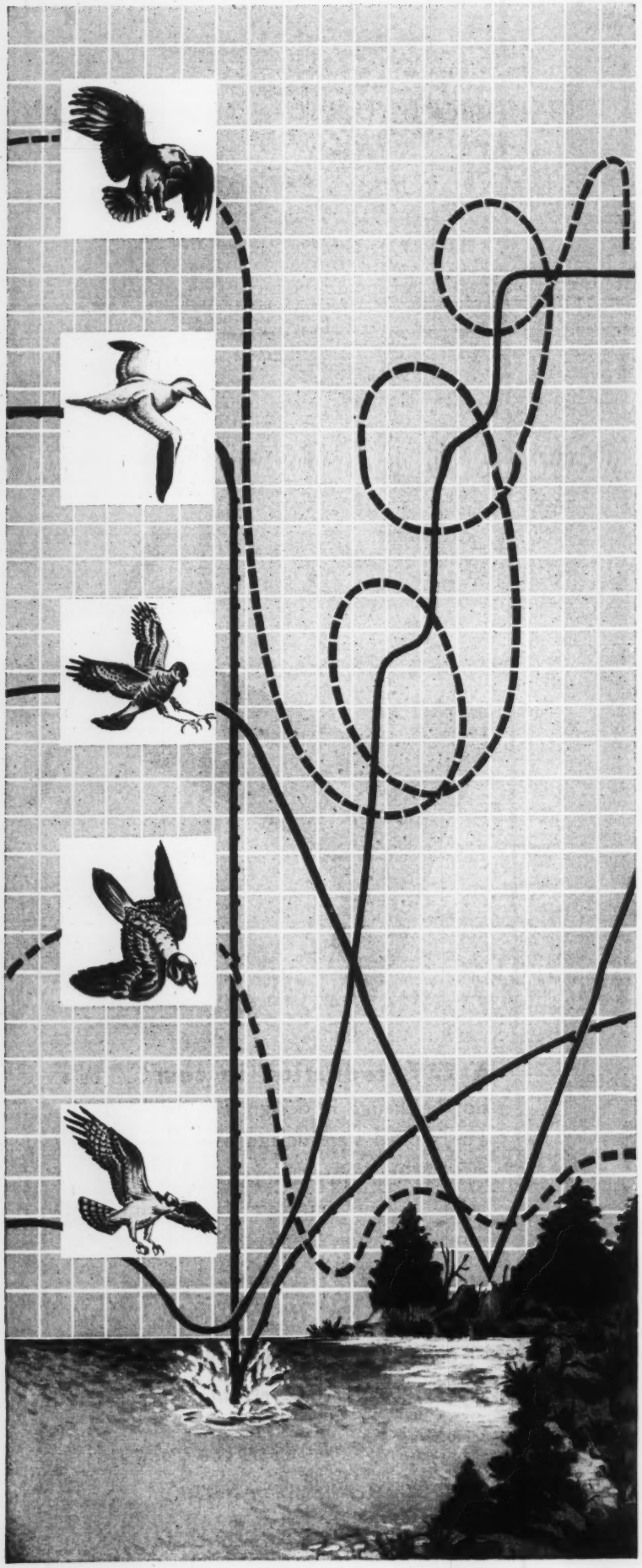
THE LINCOLN ELECTRIC COMPANY

Dept. 1111, Cleveland 17, Ohio

Creating lower costs for industry
...with welded steel

© 1956 The Lincoln Electric Company

—ITEM 236—



New Parts

sizes, with foot or sub-base mountings. Pressure ratings range to 250 psi, air, water, or oil, with maximum valve depending on use of internal or external pilot supply. **Valvair Corp.**, 454 Morgan Ave., Akron 11, O.

—Circle ITEM 85

Magnetic Counter

is reset and locked by key

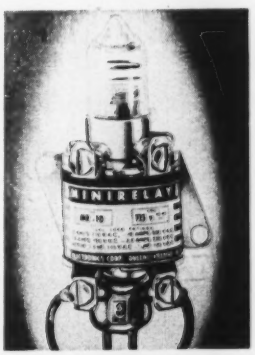
Capacity of this magnetically-operated key-lock counter is 1000 counts per minute. Six-figure display is reset to zero by one turn of key. Designed for panel mounting, the counter is 5.11 in. wide, 2.10 in. high, and 1.68 in. deep. Power consumption is 8 w, and it is available for 110 and 220 v ac or dc lines. **Veeder-Root Inc.**, Hartford 2, Conn.

—Circle ITEM 86

Miniature Mercury Relay

operates safely in explosive atmospheres

Switching capacity of this miniature mercury plunger relay is 20 amps at 115 v, 60 cps, with 30 millisecond operating time. Measuring 3½ x 1¾ x 1½ in., the Minirelay has mercury-to-mercury contacts hermetically sealed in heavy glass for safe operation in explosive, dirty, or moist atmospheres. Available contact arrangements are single pole, double throw, either



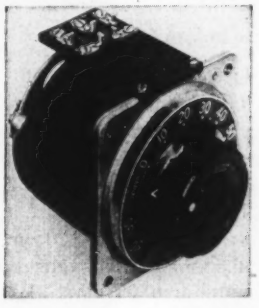
normally open or normally closed. Coils can be supplied for any desired operating voltage. For 115-v ac coil, pull-in value is 81 v and pull-out is 61 v; coil resistance is 1900 ohms and power consumption is 3.5 w. **Ebert Electronics Corp.**, 212-231 Jamaica Ave., Queens Village 28, N. Y.

—Circle ITEM 87

Variable Autotransformers

in panel-mounting or bench models

Series W-5 autotransformers have higher ratings and more rugged construction than former models. Two cased models, both totally en-



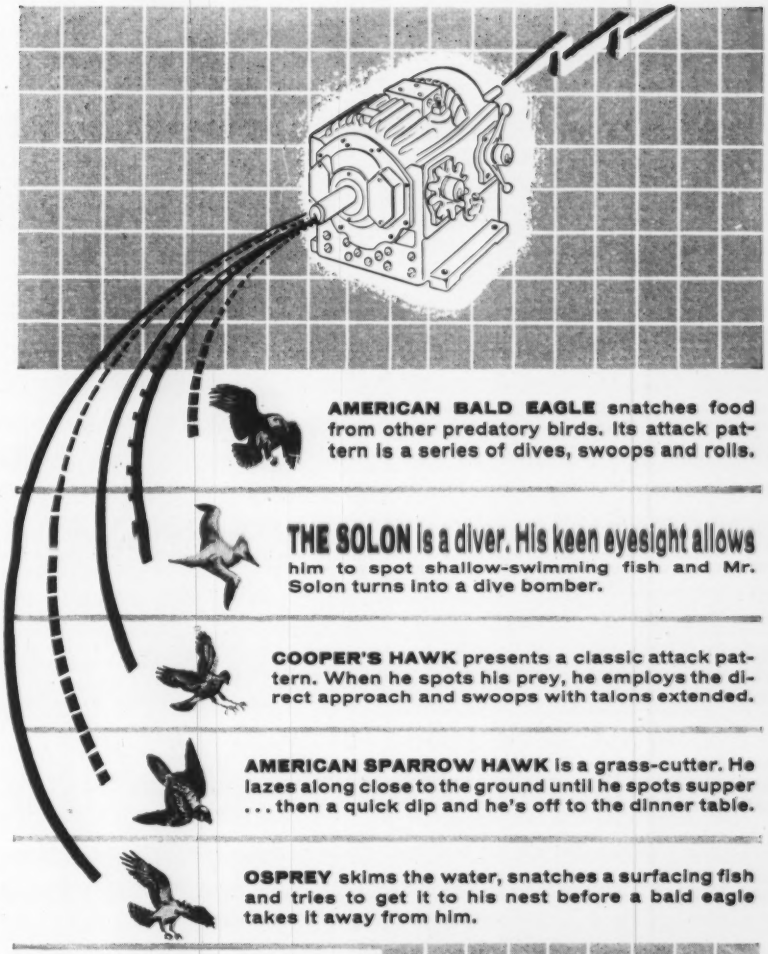
closed, are available either for panel mounting (type W5M), or for bench use (type W5MT). Ball-bearing units can be supplied for motor-driven applications. Also supplied to customer specification are two-gang and three-gang assemblies, 360 deg rotation, and dual-brush wipers. Portable models include as standard equipment: input cord and plug, resettable thermal overload protector, switch, and carrying handle. **General Radio Co.**, 275 Massachusetts Ave., Cambridge 39, Mass.

—Circle ITEM 88

Subminiature Motor

can be stopped in 2 deg shaft rotation

Intended for servo and follow-up system applications, model 206-1005 subminiature brake motor has 1.25 in. diameter and 2.00 in. length. Gear reduction in this model is 1135:1 and output speed range is 4 to 20 rpm. Other reduction ratios are available from 11.6 to 10,000:1. Torque output


AMERICAN BALD EAGLE snatches food from other predatory birds. Its attack pattern is a series of dives, swoops and rolls.
THE SOLON is a diver. His keen eyesight allows him to spot shallow-swimming fish and Mr. Solon turns into a dive bomber.
COOPER'S HAWK presents a classic attack pattern. When he spots his prey, he employs the direct approach and swoops with talons extended.
AMERICAN SPARROW HAWK is a grass-cutter. He lazes along close to the ground until he spots supper . . . then a quick dip and he's off to the dinner table.
OSPREY skims the water, snatches a surfacing fish and tries to get it to his nest before a bald eagle takes it away from him.

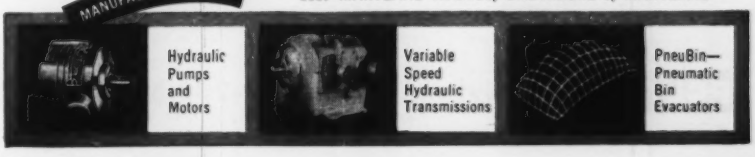
We have diagramed the attack patterns of American predatory birds as a novel way of illustrating acceleration and deceleration curves. The curves diagraming the acceleration-deceleration performances of the new GEROTOR VARIABLE SPEED HYDRAULIC TRANSMISSION would leave you gasping. We have some interesting material available on the abilities of this versatile VARIABLE SPEED HYDRAULIC TRANSMISSION. If you would like to know more . . . *write:*

GEROTOR

MAY CORPORATION

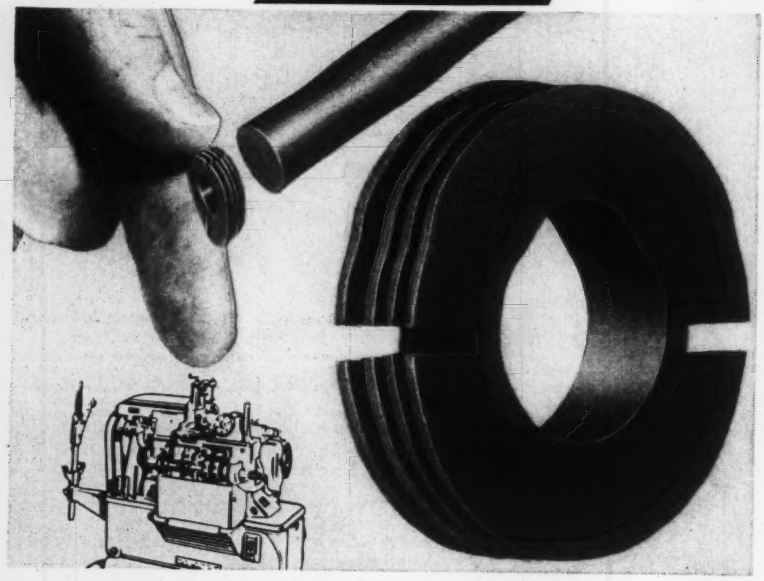
MANUFACTURERS OF—

1537 MARYLAND AVENUE, BALTIMORE 3, MARYLAND



—ITEM 237—

POLYPENCO® NYLON SHAPES



For mass production of intricate parts... fabricate from POLYPENCO shapes

This is proof that POLYPENCO Nylon Shapes offer you the *practical* solution to the production of intricate nylon parts! The small part shown above is being produced on a screw machine at the rate of 605 parts an hour. The design of the part—with undercuts and varying cross-sections—makes machining the *best* method of production from the standpoint of both accuracy and economy.

Whatever problem faces you in designing and producing nylon parts to close tolerances, it will pay you to come first to POLYPENCO:

UNIFORM QUALITY

rigid quality control means absolute uniformity in every piece and every shipment.

IMMEDIATE DELIVERY

standard shapes are stocked for immediate, off-the-shelf delivery.

RAPID FABRICATION

use standard metalworking tools for fast, simple machining.

Take the first step toward low-cost, accurate production of nylon parts. Write for latest information on applying POLYPENCO Nylon to your specific application.

THE POLYMER CORPORATION OF PENNA. • Reading, Penna.
In Canada: Polypenco, Inc., 2052 St. Catherine St. W., Montreal, P.Q.

POLYPENCO Nylon, Teflon*, Q-200.5 and K-51
Custom fabricating service available on request

*DU PONT TRADEMARK

—ITEM 238—
For More Information Circle Item Number on Yellow Card—page 19

New Parts

is 3 lb-in. at 20 rpm; current rating is 320 ma at 17 to 30 v; and duty cycle is one second on, one second off for 500,000 cycles. An internal brake stops the output shaft in 2 deg, with stopping time of 8 milliseconds. The motor meets MIL M-8609 specifications. **Motronics Corp.**, 241 Concord St., Glendale, Calif.

—Circle ITEM 89

Large Hexagon Stock

made in 3 to 4 in. sizes

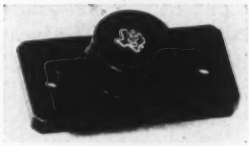
Useful for production of large nuts, bolts, and similar parts requiring the hexagon shape, large hexagon steel (C-1018 grade) is available in five sizes from 3 to 4 in. Chemistry of the bars in percent is: carbon, 0.15-0.20; manganese, 0.60-0.90; phosphorus, 0.04 max; sulphur, 0.05 max. **La Salle Steel Co.**, P. O. Box 6800A, Chicago, Ill.

—Circle ITEM 90

Silicon Power Transistor

dissipates 3.5 watts at 100 C

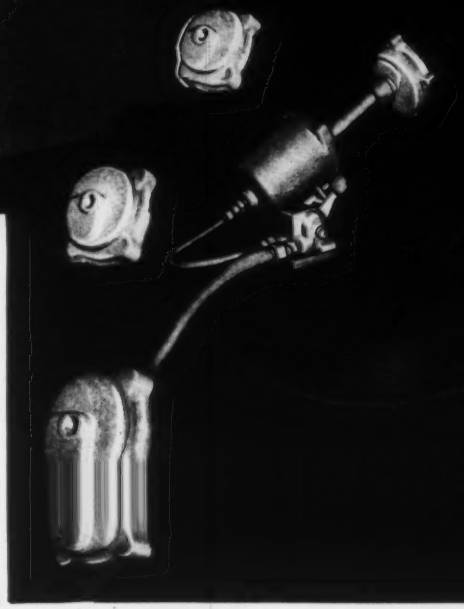
Suitable for use in servo-amplifier and similar power-output stages, type 970 silicon power transistor



dissipates 8.75 w maximum at 25 C and 3.5 w maximum at 100 C. Power gain at 100 C is 28 db at 1-w output, Class A operation; gain is 18 db at 2.5 w, Class B operation. The transistor weighs ¾ oz and is hermetically sealed in a disk measuring ½-in. diameter by ½-in. high. **Texas Instruments Inc.**, 6000 Lemmon Ave., Dallas 9, Tex.

—Circle ITEM 91

FASTER,
POSITIVE
CLAMPING



CLAMPING CYLINDERS

These Schrader Air Cylinders are available either base or leg mounted, in 1", 2¼" and 3" diameters delivering a 2" or 1" stroke. A wide selection of Schrader Valves is available, too, to operate them.

Use Schrader Air Clamping Cylinders

You can eliminate nearly all manual-holding lost time with the new Schrader Clamping Cylinder ... with no more effort than opening a valve.

These clamps—actually bantam air cylinders—have plenty of power to hold work firmly—with the same force every time ... reducing rejects.

Schrader Clamping Cylinders will serve you well on drill presses ... milling machines ... gluing operations—and scores of other places all over the shop. In all of these, production can be boosted. And remember—since this is basically a push-type air cylinder, you can use it any time you need a short, hard stroke.

Clamping cylinders are just one of the many different kinds of air cylinders that Schrader makes. They are designed to increase production and worker efficiency. Schrader's full cylinder line will give you your air control answer. Write, outlining the applications in which you are interested—or fill out the coupon below.

Schrader
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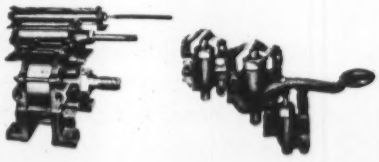
LEADERS IN AIR CONTROL SINCE 1844



The complete Schrader line of pneumatic accessories includes everything you need

A. SCHRADER'S SON
Division of Scovill Manufacturing Company, Incorporated
476 Vanderbilt Avenue, Brooklyn 38, N. Y., Dept. E-3

I am interested in more information on_____

Name_____ Title_____

Company_____

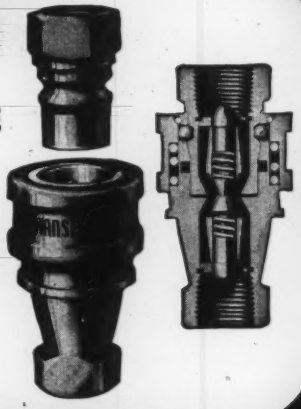
Address_____

—ITEM 239—

HANSEN

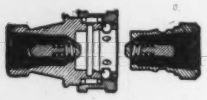
QUICK-CONNECTIVE

2-WAY SHUT-OFF COUPLINGS!



QUICK CONNECTION AND DISCONNECTION

INSTANT AUTOMATIC FLOW OR SHUT-OFF



To connect a Hansen Two-Way Shut-Off Coupling, you just pull back the sleeve and push the Plug into the Socket. To disconnect, merely pull back sleeve. No tools required. Similar valves in Socket and Plug shut off both ends of line when Coupling is disconnected—practically eliminate spilling of liquid or escape of gas at instant of disconnection.

Seals Both Ends of Line
AUTOMATICALLY INSTANTANEOUSLY

FEMALE PIPE THREAD CONNECTIONS FROM ⅛" TO 1"

Hansen Series HK Two-Way Shut-Off Couplings are available with female pipe thread connections from ⅛" to 1" inclusive. Available in brass or steel.

Also Straight-Through and One-Way Shut-Off Couplings.

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TORONTO
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Export Department: CLEVELAND

Write for Catalog

QUICK-CONNECTIVE FLUID LINE COUPLINGS
for
AIR • OIL • GREASE
HYDRAULIC FLUIDS • WATER
VACUUM • STEAM • OXYGEN
ACETYLENE • REFRIGERANTS
GASOLINE • COOLANTS

SINCE 1915 — QUICK CONNECTIVE FLUID LINE COUPLINGS

THE HANSEN MANUFACTURING COMPANY

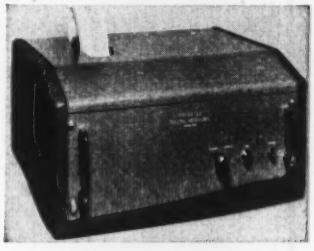
4031 WEST 150th STREET • CLEVELAND 11, OHIO

ENGINEERING DEPARTMENT
EQUIPMENT

Digital Recorder

transcribes electronic count data to 10 digits

Model 1452 Digital Recorder is new addition to a line of four-line binary code instruments. Combining a scanner and printer in a single

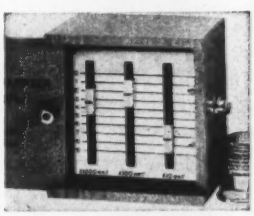


unit, it operates directly from electronic counting equipment. Automatic readouts up to 10 digits are printed in arabic numbers on ordinary adding machine tape. Since it sequentially prints total count accumulated by the basic instrument, the recorder is useful for long-term stability checks and for recording transients. Weighing 60 lb, it incorporates a stepping switch, control and interlock relays, an adding machine, and a power supply. **Beckman Instruments Inc.**, Berkeley Div., 2200 Wright Ave., Richmond 3, Calif.

—Circle ITEM 92

Decade Capacitor

standardizes pickup outputs to one voltage



This precision decade switch capacitor provides capacitance values from 10 mmf to 9990 mmf (±1 per cent) in steps of 10 mmf. It is particularly useful for standard-

Leading Motor Manufacturer Provides Top Motor Performance with Built-in KLIXON Protectors

Wagner Electric Corporation, one of the country's leading quality motor manufacturers for more than 60 years, knows the value of Klixon inherent overheat motor protection . . . knows how it gets more work out of motors yet protects them from burnouts — that is why Wagner includes built-in Klixon Protectors in their *new* Type RK Capacitator — Start and Type RB Split-Phase Motors.

In addition, Wagner offers many other fractional HP Motors with Klixon inherent overheat protection. This outstanding feature is available by simply specifying "Klixon Protection" on your purchase order.

The reason . . . their experience proves that Klixon Protectors can be depended on to prolong the life of a motor operating under adverse conditions by always providing positive overheat protection.

Should the motor become dangerously overheated because of overloads, stalled rotor or other causes, the Klixon Protector snaps the power "off". When the motor cools sufficiently, the Protector snaps the power "on".

You, too, can keep motors in your equipment operating, reduce service calls and repairs by specifying and using Klixon protected motors. The additional cost is low, pays for itself over and over by protecting against motor burnouts and unnecessary shutdowns.

KLIXON

METALS & CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
3203 FOREST STREET, ATTLEBORO, MASS.

—ITEM 241—
For More Information Circle Item Number on Yellow Card—page 19

Mr. Design Engineer:

Durakool is the Life of Your Automatic Controls

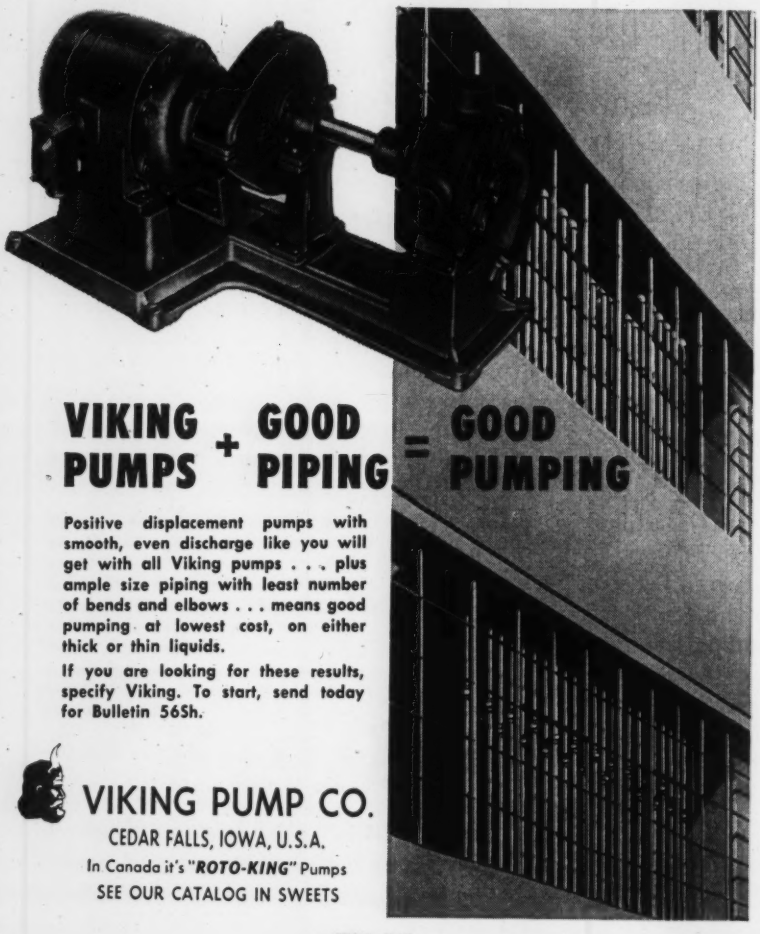
MILLIONS OF CYCLES WITHOUT FALTERING

This steel-clad Durakool mercury tilt switch has unique construction features that deliver years of trouble-free performance on the most difficult assignments you can find. Operating under sealed-in, pressurized hydrogen gas, it takes 24 hours, fast cycling schedules in stride. 7 sizes, 1 to 65 amperes.
Send for Bulletin 525.

See telephone directory for local distributor, or write.
DURAKOOL, INC.
ELKHART, INDIANA, U.S.A. • 700 WESTON RD., TORONTO, CANADA

Durakool ALL-STEEL MERCURY *Switches*

—ITEM 242—



VIKING PUMPS + GOOD PIPING = GOOD PUMPING

Positive displacement pumps with smooth, even discharge like you will get with all Viking pumps . . . plus ample size piping with least number of bends and elbows . . . means good pumping at lowest cost, on either thick or thin liquids.

If you are looking for these results, specify Viking. To start, send today for Bulletin 56Sh.

VIKING PUMP CO.
CEDAR FALLS, IOWA, U.S.A.
In Canada it's "*ROTO-KING*" Pumps
SEE OUR CATALOG IN SWEETS

—ITEM 243—

izing the voltage output from self-generating pressure, force, and acceleration pickups to one value of output voltage. Groups of pickups can be standardized to within 1 per cent. Environmental limitatons are those of silver mica capacitors. **Endevco Corp.**, 161 E. California St., Pasadena, Calif.

—Circle ITEM 93

Contact Switch Kit

contains all components for switch construction

Designed as an aid to experimenters and to facilitate construc-

tion of electrical control circuits, this switch contact kit provides all components necessary for the assembly of a great variety of contact switches. Kit has assortments of contact blades, insulators, separators, tension plates, brackets, nylon lifters, rivets, washers, screws, and bushings. Switch blades are furnished in both standard and midget sizes. **Guardian Electric Mfg. Co.**, 1621 W. Walnut St., Chicago 12, Ill.

—Circle ITEM 94

Intervalometer

provides timing pulses accurate to 0.5 per cent

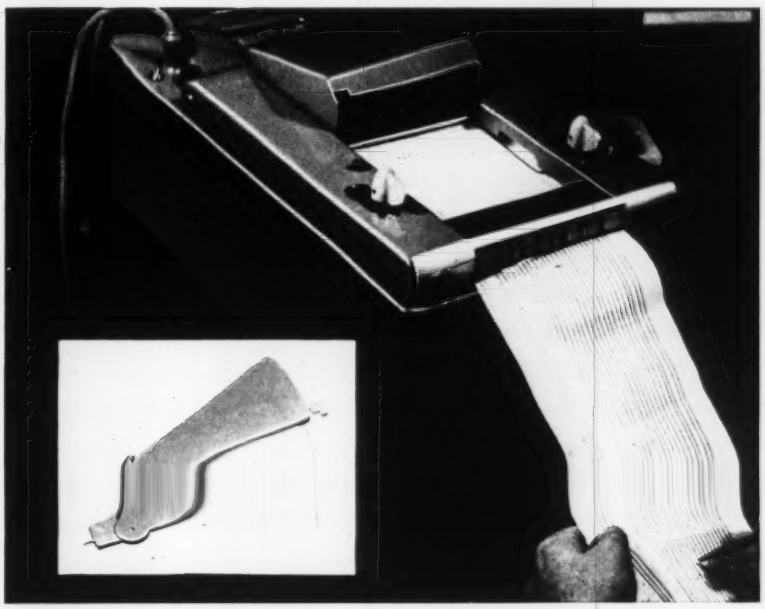
Pulse rates from 1 to 10 per second and time intervals from ½ to 10 seconds are supplied by model N-20 Intervalometer. Accuracy of intervals and pulses exceeds 0.5-per cent. Designed for automation, process control, test control, and similar applications, the unit can be furnished with pulse durations and intervals to meet special requirements. Contact current rating is 10 amp, noninductive. Temperature range is −50 to +

DU PONT
REG. U.S. PAT. OFF.

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

PRODUCT ENGINEERING NEWS

Design problem in new work monitor solved by ZYTEL® nylon resin



The operator can check machines remotely, using this 30-channel Alden recorder. Marking electrodes, housed in "Zytel" nylon resin, trace impulses on electrosensitive paper. "Zytel" is used because of its insulating properties, and its strength in thin sections. (Recorder manufactured by Alden Electronic & Impulse Recording Equipment Company, Westboro, Massachusetts.)

Du Pont "Zytel" provides needed insulation in strong, lightweight parts.

WITH the Alden 30-channel work recorder, up to 30 machines can be monitored remotely and their records studied for optimum scheduling. Tiny Alden motion switches mounted on the machines and activated by machine motions transfer electrical currents to the recorder. The currents then activate marking electrodes that mark out lines on electrosensitive paper, providing a permanent record of operation cycle and downtime.

PROBLEM . . .

One of the problems in developing the recorder was to find a material to house the marking electrodes. It had to be lightweight (only 3 grams pressure needed to record), strong, provide good insulating properties, and be economical to produce.

. . . SOLUTION

The manufacturer solved the problem with Du Pont "Zytel" nylon resin. This engineering material is strong, even when molded in thin sections. The metal inserts form an integral part of the marking electrodes because "Zytel" can be injection-molded around these inserts. The holders of "Zytel" can be produced in a variety of attractive colors.

The wide range of properties available in "Zytel" nylon resin is solving many design problems for industry. Molded "Zytel", for example, because of its inherent impact resistance, resilience, toughness and good bearing characteristics, is used in all types of mechanical parts—bearings, gears, cams, rollers, spools, bushings, and hundreds of others—across such representative industries as textile, automotive, aircraft, household appliance, electrical, and business machine.

FOR MORE INFORMATION, MAIL COUPON

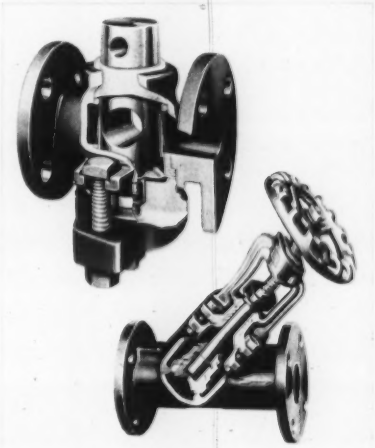
OVER

Disc rings and sleeves of TEFLON® increase valve life

DISC RINGS AND SLEEVES of "Teflon" tetrafluoroethylene resin give a tight seal against pressure and vacuum. They have good impact strength and abrasion resistance under normal conditions. Toughness and flexibility are retained at extreme temperatures.

"Teflon" has zero water absorption—won't shrink, crack, swell or harden because of moisture. It's inert to all chemicals except alkali metals and fluorine under special conditions.

These remarkable properties have reduced maintenance time, increased service life and efficiency for Durco Type F plug valves and Types J and K "Y" valves manufactured by The Duriron Company, Inc., Dayton, Ohio.



Durco Type F valve with a sleeve of "Teflon" avoids metal-to-metal contact, and assures dependable service with no sticking. The "Y" valve has disc ring and stem packing of "Teflon" for longer service, positive sealing.

FOR MORE INFORMATION, MAIL COUPON

DU PONT

REG. U.S. PAT. OFF.

Better Things for Better Living ... through Chemistry

PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

ZYTEL® nylon resin fills need for long wearing, lightweight parts in new speed governor

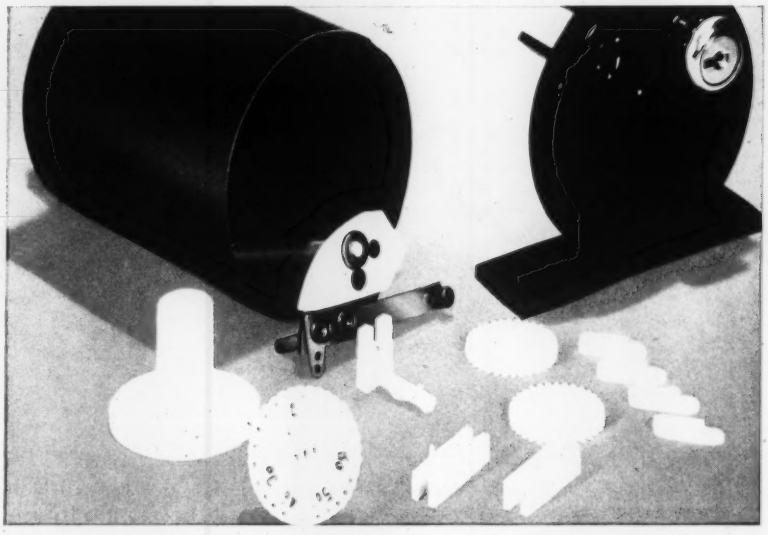
Slotted tubes of ALATHON® extend battery life

THE TUBES in this Exide-Ironclad industrial battery are extruded from "Alathon" polyethylene resin. They are slotted, as shown in the illustration, to permit the active material on the surface of the core to be exposed to the electrolyte. With these slotted tubes, the active material is retained better during the charge-discharge cycle and the working life of the battery is extended.

The decision to switch from rubber tubing material to "Alathon" was made by Exide after years of research, field testing and successful use. Exide engineers expect an increase of up to 20% in battery working life as a result.

"Alathon" won't corrode or erode. It is lightweight, flexible, and strong. Low temperatures will not affect the strength and flexibility of this engineering material. (Batteries manufactured by the Electric Storage Battery Company, Philadelphia, Penna.)

FOR MORE INFORMATION, MAIL COUPON



Including the case, fourteen parts of Du Pont "Zytel" nylon resin are used on this governor. "Zytel" is durable and provides the lightness necessary to minimize inertia—the parts weigh only 5½ ounces. Parts molded of "Zytel" by F. J. Kirk Molding Company, Clinton, Massachusetts.)

THIS SPEED GOVERNOR is mounted under the dashboard of a car or truck. When allowable speed is exceeded, a set of contacts in the governor breaks the vehicle's ignition circuit and thus controls the vehicle's speed.

Including the case, fourteen parts of Du Pont "Zytel" nylon resin are used on the governor. "Zytel" offers the good electrical properties needed in this application and is light in weight to help minimize the inertia of the moving parts. It also offers exceptional abrasion resistance and bearing properties which help reduce wear. In a recent test, the governor was run continuously for two weeks at a speed equivalent to 600 mph. Absolutely no wear was visible on the bearings, gears or other moving parts.

Intricately shaped precision pieces like gears and bearings can be mass-produced by the injection molding process when made of "Zytel" ... these parts usually require no further finishing. The method is efficient and can mean substantial savings in production costs.

For complete information on properties and application data of Du Pont "Zytel" nylon resin, write to Polychemicals Department, E. I. du Pont de Nemours & Co. (Inc.), Du Pont Building, Wilmington 98, Delaware.

E. I. DU PONT DE NEMOURS & CO. (Inc.) POLYCHEMICALS DEPARTMENT
Room 123, Du Pont Building, Wilmington 98, Delaware.
In Canada: Du Pont Company of Canada, Ltd., P. O. Box 660, Montreal, Quebec.

Please send me more information on the Du Pont engineering materials checked: ☐ *"Zytel";* ☐ *"Alathon";* ☐ *"Teflon";* ☐ *"Lucite". I am interested in evaluating these materials for:*

NAME _____ POSITION _____

COMPANY _____

STREET _____

CITY _____ STATE _____

TYPE OF BUSINESS _____

*"Alathon", "Lucite", "Teflon" and "Zytel" are registered trade-marks of E. I. du Pont de Nemours & Co. (Inc.)

Investigate DuPont engineering materials in your product development programs

One of the family of these versatile engineering materials is often a key factor in product improvement or new product design. The wide range of properties, available with "Alathon"* polyethylene resin, "Lucite"* acrylic resin, "Teflon"* tetrafluoroethylene resin, and "Zytel"* nylon resin, are helping solve industrial design problems.

NEED MORE INFORMATION? Clip the coupon for additional data on the properties and application of these Du Pont engineering materials.

Engineering Equipment

150 F. **Photographic Products Inc.,** 1000 N. Olive St., Anaheim, Calif.

—Circle ITEM 95

Gear Train Kit

has twenty gear clusters

Universal precision gear train kit, consisting of anodized aluminum housing packaged with 20 stainless-steel gear clusters, is designed for breadboard setup of computing devices, servomechanisms, controls, and similar electrochemical equipment. Designated 107U, the set includes Oilite cluster bearings and ball-bearing supported input and output shafts. **Bowmar Instrument Corp., 2425 Pennsylvania St., Fort Wayne, Ind.**

—Circle ITEM 96

Surface Thermometer

is made of stainless steel

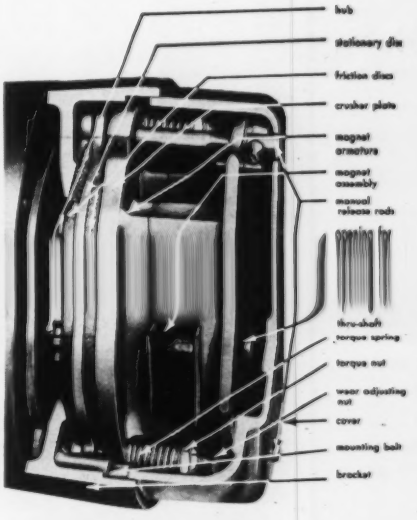
Designed for spot checking surface temperatures, stainless steel surface thermometer indicates temperatures to ± 2 per cent within the range 50 to 1000 F. It can also be used to read temperatures in furnaces and ovens and will operate while immersed in noncorrosive liquids and gases. Thermal stability of the unit is reached 60 seconds after it is placed on a hot surface. Diameter is 1¾ in. and weight is 1/3-oz. **Pacific Transducer Corp.,** 11836 W. Pico Blvd., Los Angeles 64, Calif.

—Circle ITEM 97

Here's why you should specify

DINGS *Direct-Acting* MAGNETIC DISC BRAKES!

Wherever you require a quick, smooth stop and dependable holding, with low maintenance costs . . . that's the place for Dings Magnetic Brakes. Simply designed and ruggedly built, these efficient units are *direct-acting* for instantaneous release and positive stops. There are no mechanical linkages and levers to maintain. Designed for mounting on all old and new re-rated NEMA type "C" motor flanges. *Always specify Dings Brakes* from your regular motor supplier . . . ask about Dings complete engineering service for your brake problems.



THRU-SHAFT DESIGN

While a Dings Brake accommodates the standard NEMA shaft extension, eliminating the necessity of using special shaft extensions, a simple modification of the cover converts the brake for Thru-Shaft applications. This facilitates direct coupling, use of hand cranks, tachometer, plugging switch, pulleys, etc.

Write for Bulletin BK4003

DINGS BRAKES, INC.
A SUBSIDIARY OF DINGS MAGNETIC SEPARATOR CO.
4714 West Electric Avenue
Milwaukee 46, Wisconsin

See our Catalog in SWEETS PRODUCT DESIGN FILE. Section 5a/Di

DB156

—ITEM 245—

ILSCO CONNECTORS

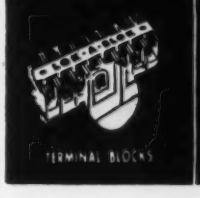
MAKE YOUR PRODUCT PERFORM BETTER

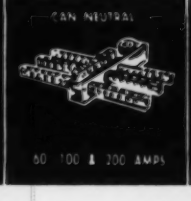
All these . . . and more . . . for YOUR BEST CONNECTIONS

U/L AND CSA TESTED | HI-RUGGED STRENGTH
PURE COPPER | RE-USABLE
100% CONDUCTIVITY | ALL WIRE SIZES
COOLER OPERATION | ECONOMICAL

WRITE FOR 80-PAGE CATALOG

ILSCO CORPORATION
5752 Mariemont Ave.
CINCINNATI 27, OHIO



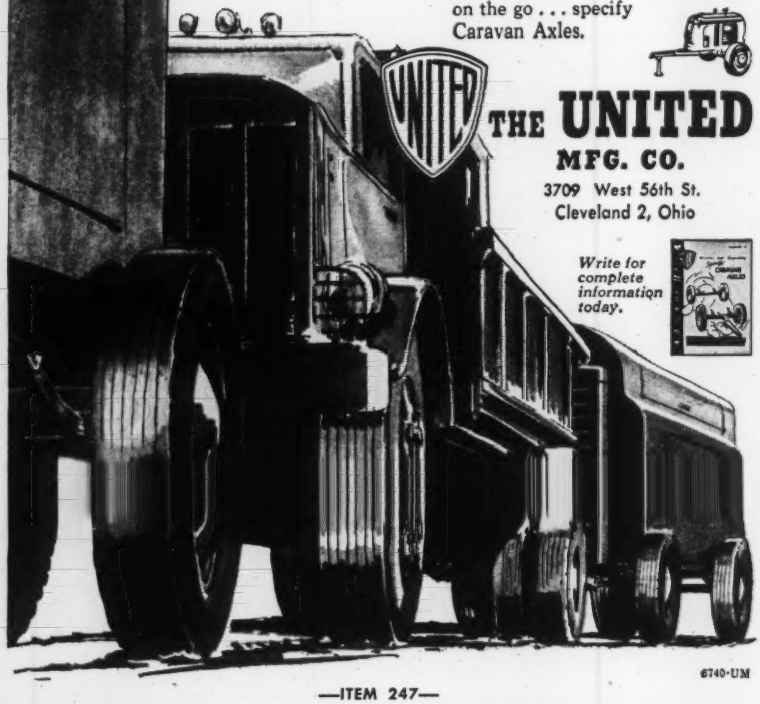


—ITEM 246—

MILE AFTER MILE...

CARAVAN AXLES keep equipment on the go!

Designed and constructed for heavy load stability and safety . . . Caravan Axles are your best bet for guaranteed dependability. Units can be furnished in two-wheel single-axle assemblies or in four-wheel running gear equipped with automotive-type steering mechanism. Both straight and drop-axle type construction are available. To keep equipment on the go . . . specify Caravan Axles.



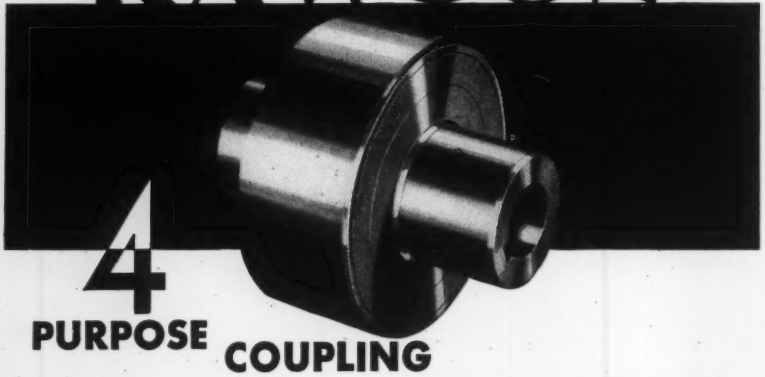
THE UNITED MFG. CO.
3709 West 56th St.
Cleveland 2, Ohio

Write for complete information today.

6740-UM

—ITEM 247—

RAWSON



4 PURPOSE COUPLING

Starts . . . couples . . . cushions . . . limits load

"Rawson" four-duty coupling is an automatic centrifugal clutch consisting of two drum-shaped members—one attached to the driver shaft—and between them two sets of floating shoes made of various friction materials. Simplicity in design and action—the "Rawson" Coupling smoothly transmits the loads between motor and machine in hundreds of varied applications.

RAWSON COUPLING DIVISION
O. S. WALKER CO., INC., Worcester, Massachusetts

—ITEM 248—

THE ENGINEER'S Library

Recent Books

Switching Relay Design. *By R. L. Peek Jr. and H. N. Wagar, technical staff members, Bell Telephone Laboratories: 480 pages, 6 by 9 inches, clothbound; published by D. Van Nostrand Co. Inc., 250 Fourth Ave., New York; available from* MACHINE DESIGN, *$9.50 postpaid.*

This text provides an analytical approach to the design of the mechanical contacting systems and the actuating electromagnets of switching relays. Procedures are given for evaluating the characteristics of existing relays and for predicting performance of proposed designs. Four chapters are grouped as fundamentals of relay design and seven chapters concern analytical background of design.

♦

Atomic Energy Guidebook. *Edited by Walter A. Shead; 95 pages, 8½ by 11 inches, paperbound; published by and available from* The Atomic Energy Guideletter, *1420 New York Ave. N.W., Washington 5, D. C.; $7.50 per copy.*

Directed to industrial managers and executives, this booklet is a source of nontechnical information on atomic energy. The first section explains how to enter the atomic energy business. It describes radioisotopes and reactors, and gives the essentials of atomic energy industrial tools. The second section gives basic information on the status and future of atomic energy. A directory of the atomic energy field is included.

♦

Principles of Metal Casting. *By Richard W. Heine, associate professor of mining and metallurgy, and Philip C. Rosenthal, professor of mining and metallurgy, both of the Uni-*

VOLUME makes the GEARS GO 'ROUND

R. W. Melter

MASTER MECHANIC, THE CINCINNATI GEAR CO.

Do you know what a small spiral bevel gear generator costs at today's prices? Approximately $35,000! And the cost of the work done by this machine represents on the average only about 15% of the total cost of producing a spiral bevel gear. Thus you can see it requires *volume* production and *maximum* utilization to make such expensive, specialized equipment pay off. And yet without such equipment, whether it be this spiral bevel gear generator or any one of the other pieces of capital equipment in our plant, it would be impossible to produce quality custom gears at a competitive price.

The sales and production departments have a big responsibility to keep these machines busy and earning their keep, but their efforts would be wasted if we didn't have the *right* tools in the first place. It is my job to see to it that we *have* these tools — that our plant is equipped with the most modern and efficient equipment available — through continuing re-evaluation of our present installations and constant searching for new and improved machines. When I can find equipment which would be superior to present equipment, I take the facts to top management. I've found in my 43 years' experience that in a progressive firm like ours these recommendations are usually acted on favorably — and promptly. That's how we manage to maintain a completely modern gear manufacturing plant, and thus produce progressively better gears more efficiently for you, our customer.

THE CINCINNATI GEAR CO.
CINCINNATI 27, OHIO
"Gears — Good Gears Only"

—ITEM 249—

The Engineer's Library

versity of Wisconsin; 639 *pages,* 6 *by* 9 *inches, clothbound; published by McGraw-Hill Book Co. Inc.,* 330 *West* 42*nd St., New York* 36, *N. Y.; available from* MACHINE DESIGN, $7.50 *postpaid.*

The authors have arranged this text so that it can be used either as a survey of general foundry processes or as more complete coverage of basic foundry metallurgy. Concerned only with the casting of metals, the text covers patterns; molding processes, materials and equipment; cores and core materials. Separate chapters treat the metallurgy and casting practices for groups of related alloys. Extensive bibliographies follow the chapters.

•

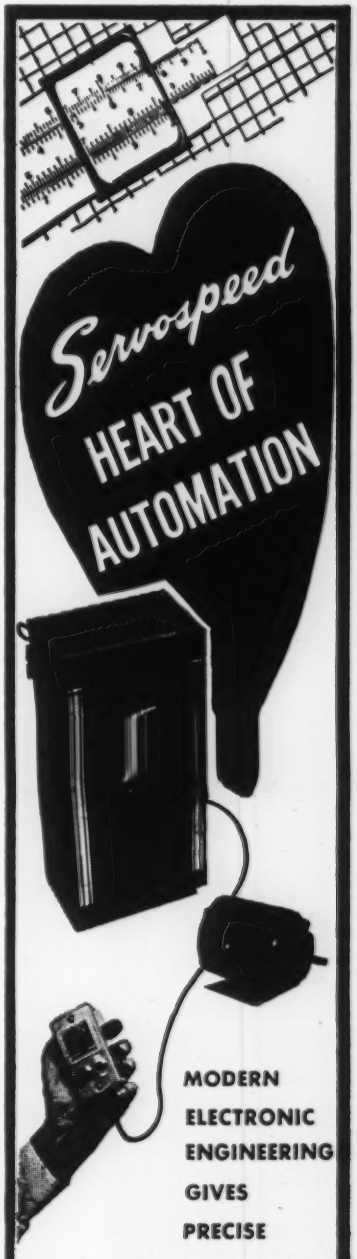
Chemical Engineering Materials. *By Frank Rumford;* 380 *pages,* 5¼ *by* 8½ *inches, clothbound; published by Chemical Publishing Co. Inc.,* 212 *Fifth Ave., New York* 12, *N. Y., available from* MACHINE DESIGN, $7.50 *postpaid.*

This book is directed to both mechanical and chemical engineers who must work together in the design and planning of chemical plants. It provides general rules for the selection of engineering materials, explains the general mechanism of chemical attack and describes methods of material testing. In addition to specific metals and alloys, the text covers protective coatings, refractory materials, wood, plastics and rubber.

New Standards

1955 Book of ASTM Standards, Part 1, Ferrous Metals. 1834 *pages,* 6 *by* 9 *inches, clothbound; published by and available from the American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.,* $13.50 *per copy.*

Successor to the 1952 edition, this compilation of ASTM documents contains 315 standards of which many are new or revised since the 1954 Supplement. Included are standard and tentative specifications, methods of test and



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—ITEM 250—

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● The investment casting process is, of course, especially suited for complicated parts like this impeller. We pour hundreds of these "assemblies", which could not be produced by any other means. It isn't surprising, therefore, if a designer thinks only in terms of such impossible-to-machine parts.

Actually, Precision Metalsmiths cast hundreds of parts that seem quite simple in shape. But when you get to figuring the cost of blanking, forming, machining and finishing that is eliminated in the two castings pictured here, you understand. That knitting needle, for example, needs only to be polished before it's ready for work.

Why not look over some of your drawings and let us check your costs? The book, "Pour Yourself an Assembly", describes many of these parts. For a copy, write Precision Metalsmiths, Inc., 1083 East 200th Street, Cleveland 17, Ohio.

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INVESTMENT CASTINGS

The Engineer's Library

definitions for commercial forms and certain end-products of iron and its alloys.

Association Publications

Elevated-Temperature Properties of Carbon Steels. *ASTM Special Technical Publication No.* 180; *prepared by Ward F. Simmons and Howard C. Cross;* 63 *pages,* 8½ *by* 11 *inches, paperbound; published by and available from American Society for Testing Materials,* 1916 *Race St., Philadelphia;* $3.75 *per copy.*

This report is a graphical summary of elevated - temperature strength data for carbon steels. It includes curves for tensile strength, 0.2 per cent offset yield strength, per cent elongation and reduction of area, stresses for rupture in 100 hr to 100,000 hr, and stresses for creep rates of 0.0001 and 0.00001 per cent per hr. Compilation of the data was a joint project of the ASTM and ASME.

•

The Four Hundred American Standards in the Electrical Field. 60 *pages,* 8½ *by* 11 *inches, paperbound; published by and available from American Standards Association,* 70 *East* 45*th St., New York* 17, *N. Y.*

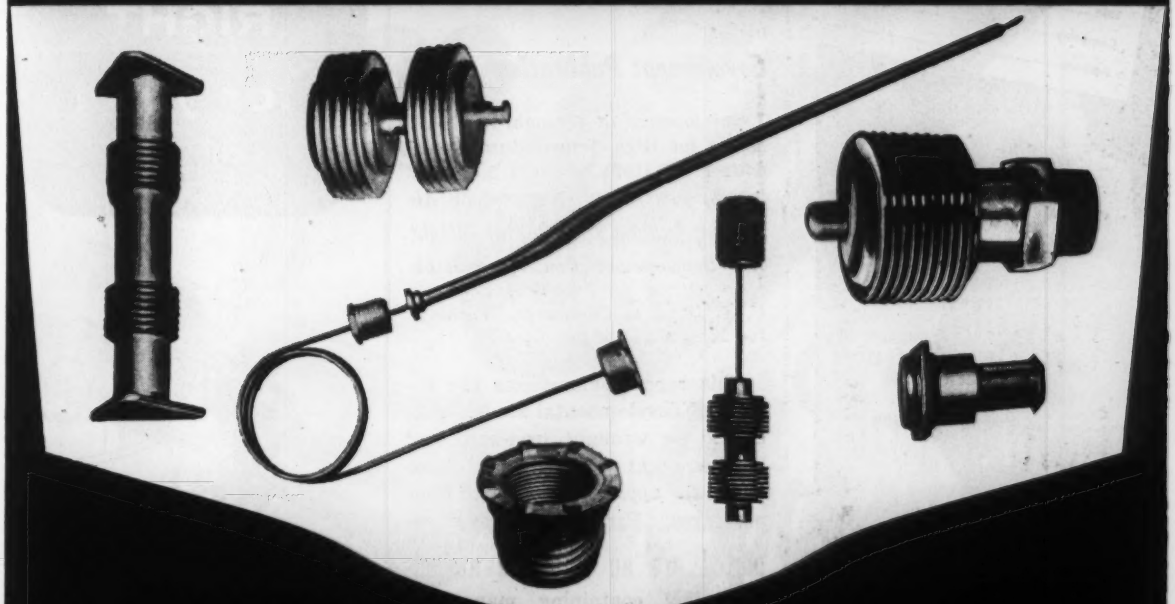
Designed to help the user and prospective purchaser of electrical items, this booklet contains indexes and brief descriptions of each American Standard in the electrical engineering field. It also contains briefs of each of the current International Electrotechnical Commission recommendations.

Manufacturers' Publications

Machining Kaiser Aluminum. 320 *pages,* 5¼ *by* 8¼ *inches, clothbound; available from Technical Editor, Kaiser Aluminum & Chemical Sales Inc.,* 228 *North LaSalle St., Chicago* 1, *Ill., on company letterhead request, or* $2.00 *per copy.*

Directed to engineering, production and plant personnel, this reference book summarizes methods of cutting aluminum and corre-

HOW TO SAVE TIME AND MONEY ON COMPLETE BELLOWS ASSEMBLIES



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—ITEM 252—

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Company
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—ITEM 253—

The Engineer's Library

sponding tooling practices. General headings cover milling, turning, drilling, reaming, tapping, boring, shaping, planing, broaching, grinding, filing, sawing and nibbling. Sections discuss types of machines and cutting tools, tool sharpening, speeds and feeds.

Government Publications

Development of Wrought and Cast Alloys for High Temperature Applications, PB 11891. *84 pages, 8 by 10⅝ inches, paperbound; prepared by Allegheny Ludlum Steel Co. for Wright Air Development Center; available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C., $2.50 per copy.*

This report summarizes the results of developmental studies conducted on wrought iron-base and both wrought and cast cobalt-base alloys for applications at high temperatures. Particular alloys reported are an iron-base austenitic alloy containing manganese and chromium modified with boron and a wrought cobalt-base alloy with satisfactory stress-rupture properties at 1600 and 1700 F.

•

NACA Technical Series. *Each publication is 8 by 10½ inches, paperbound, side-stapled; copies available from National Advisory Committee for Aeronautics, 1924 F St. N.W., Washington 25, D. C.*

The following Technical Memorandums are available:

1384. **Metallography of Aluminum and Its Alloys Use of Electrolytic Polishing**—80 pages.

1396. **From Linear Mechanics to Nonlinear Mechanics**—20 pages.

The following Technical Notes are available:

3413. **Investigation of the Use of a Rubber Analog in the Study of Stress Distribution in Riveted and Cemented Joints**—97 pages.

3414. **Influence of Temperature on Creep, Stress-Rupture, and Static Properties of Melamine-Resin and Silicone-Resin Glass Fabric Laminates**—71 pages.

3463. **Investigation of the Vibration of a Hollow Thin-Walled Rectangular Beam**—24 pages.

3464. **Influence of Shear Deformation of the Cross Section on Torsional Frequencies of Box Beams**—23 pages.

3495. **Failure of Materials Under Combined Repeated Stresses with Superimposed Static Stresses**—69 pages.

3542. **Analysis of Stresses in the Plastic Range Around a Circular Hole in a Plate Subjected to Uniaxial Tension**—39 pages.

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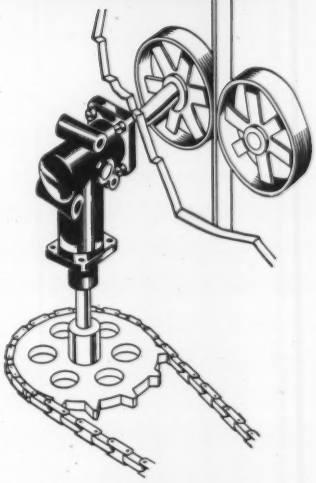

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—ITEM 254—

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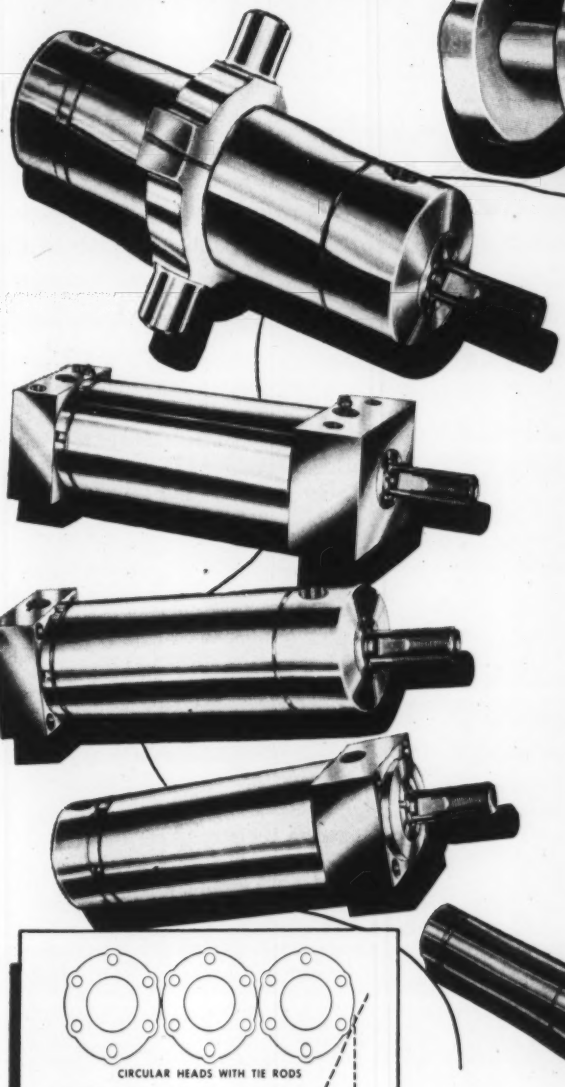

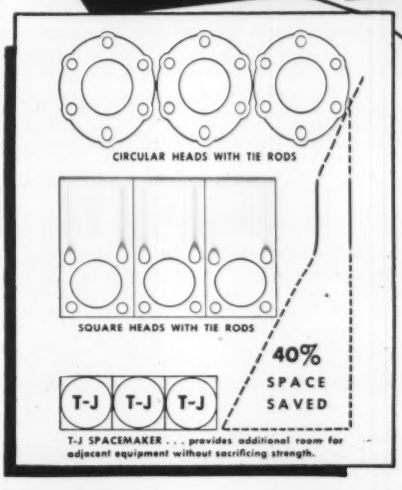
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—ITEM 255—

Norgren RELIEF VALVES Protect Your Air Equipment from Excessive Pressure Build-Up

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Model 62AX2
¼" pipe size

AUTOMATIC PROTECTION
Norgren Relief Valves automatically protect fluid lines and connected equipment from damage resulting from excessive pressure build-up, and provide controlled operation of fluid recirculating systems.

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Norgren Relief Valves can be set to relieve automatically at a specified pressure. ⅛", ¼", ⅜", ½" pipe sizes available with maximum relief settings at 15 psi, 50 psi, 75 psi, 125 psi, or 250 psi; ¾" and 1" sizes available for maximum relief settings at 15 psi, 50 psi, 75 psi or 125 psi. Pressure settings remain constant.

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The diaphragm is made of strong, tough, nylon-reinforced synthetic rubber and its large area assures you of positive valve action and close control of operating pressure.

POP SAFETY VALVES

Norgren Pop Safety Valves prevent the build-up of dangerous, excessive pressures on air tanks. When the tank pressure exceeds the valve's relief pressure setting, the valve automatically pops open and rapidly releases air from the tank. When the tank pressure returns to a safe load, the valve automatically closes. Performance of these valves is not affected by vibration. ⅛", ¼", ⅜", ½" pipe sizes.

Model 1003
⅜" pipe size

LOW FLOW RELIEF VALVES

Small, inexpensive, low capacity valves suited for a wide variety of uses—for relieving low-volume air compressors, as automatic relief of secondary pressure on cylinder gas regulators, as a small water relief valve, and similar uses requiring relief at low rates of flow. ⅛" and ¼" pipe sizes.

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Wherever Air is Used in Industry

Professional Viewpoint

FINDING more engineering capacity seems to be a problem that will be common to many companies for some time beyond tomorrow. The following discussion presents some ideas that may prove helpful to the cause. Roy F. Watson Jr., Kearfott Co. Inc., Little Falls, N. J., is the author.

A Shortage of Engineers?

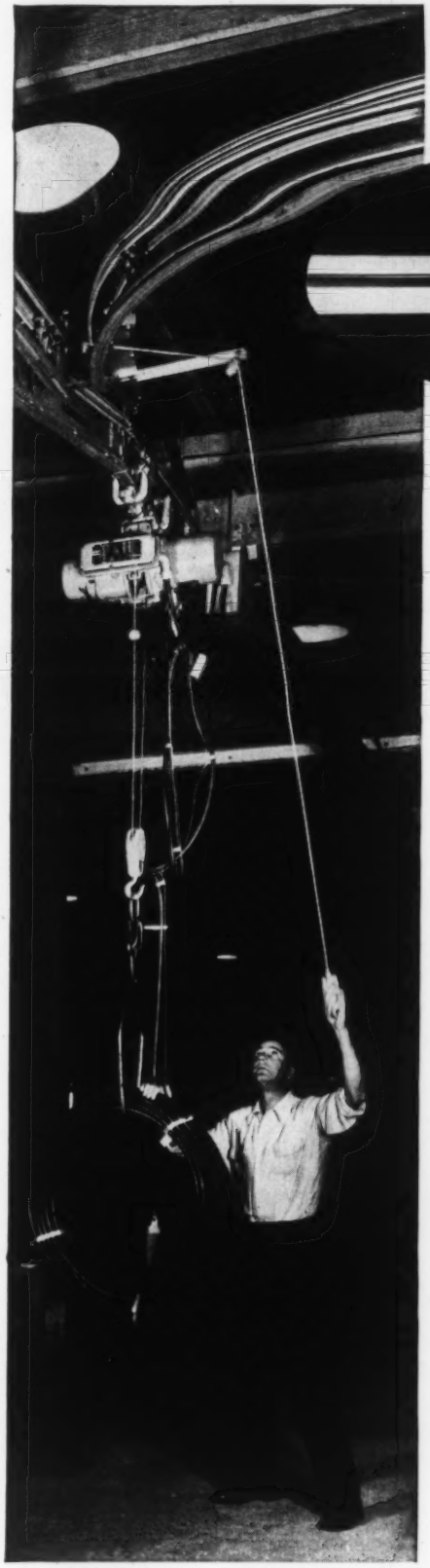
Everyone engaged in technical work, either government contract or private industry, seems to be in dire need of engineers and skilled technicians. Engineers are not as plentiful as we would like to see them. Advertising and recruiting campaigns, and lucrative starting salaries all tend to point up the great need for more and more engineers. The demand seems insatiable and grows with each passing month. Need for additional engineering capacity forces companies to turn away new business and tends to limit a company's expansion.

But what about utilization of existing personnel? What need does a company have for additional engineers if they do not use their present staffs advantageously? The majority of companies with large or medium-sized engineering forces have tended to use engineers where they cannot fully utilize their engineering and creative capabilities. Very often engineers are given responsibilities that should and could be handled by other personnel — expediting parts from vendors or from plant machine shops, personnel responsibilities over and above those directly related to his position, financial responsibilty, publications and sales functions involving his related projects, etc. Time spent on these fringe jobs is lost forever!

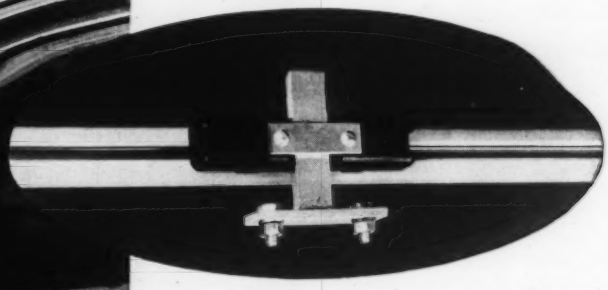
The shortage of engineers can be counteracted by conservation. Engineering departments must necessarily be organized or reorg-

Another new development using

B. F. Goodrich Chemical *raw materials*



B. F. Goodrich Chemical Company does not manufacture this extrusion. We supply only the Geon rigid vinyl materials.



Rigid Geon packs power in small space

NAKED wires on an overhead power lift are a hazard, lose power along the line and have to be spaced widely where multiple electrical contacts are needed in large plants. As a product improvement, a manufacturer has designed U-shaped extruded insulation made of Geon rigid vinyl that has many advantages for the job.

The rigid vinyl extrusion carries a metal contact conductor safely so that as many as three to twelve power lines can be installed close together where space is tight. Because this insulation is made of Geon rigid vinyl it has high dielectric strength, high insulation resistance with low power loss. It has good chemical and abrasion resistance, necessary for long life in industrial plants and it can be colored according to local code requirements.

This installation you see here is a good example of a new use for Geon rigid vinyl. It may suggest a new use to you or may give you an idea for another saleable product. There are scores of other uses for Geon materials from rigid sheeting to rigid pipe and fittings. For technical help in the uses of versatile Geon please write Dept. DO-2, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

CHEMICAL PROGRESS WEEK-APRIL 23-28

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—ITEM 257—

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—ITEM 258—

Professional Viewpoint

anized with emphasis on conserving engineers' time. Engineering departments should be staffed with competent executive administrators who have the necessary authority to act as business managers. Men who know engineers' needs and methods of operation must be used to make the roads for development and research easily passable. Good administration means having the tools to work with when they are needed. Every hour wasted waiting for raw material, parts or tools, can never be recovered. Poor management of engineering divisions wastes the engineering talent available within the organization. How many times have we seen engineers handling jobs that a lab technician or machinist—or clerk—could do?

Engineers should be used sparingly for administrative positions. Why have a chief engineer sign requisitions for proprietary items, petty cash slips, move tickets, package passes, checks and who knows what else? People can be hired to do this work, and the boss won't be sensitive about it. He knows no one wants his job!

A good administrator can be a big help to an executive if he has the authority to do a job. Engineering departments need to be directed by chief engineers or VP's but supporting organizations under a business manager should have equal stature in the company.

Engineering departments operate efficiently and effectively when they operate as entities. General company procedures should be in effect, but internal operations should be co-ordinated by the chief engineer and the business manager. The red tape must be eliminated and smoother operations initiated. The chief engineer should have engineering responsibility, and the business manager should carry the load of administrative problems involved in operating the engineering department as an efficient and effective division.

This principle of organization is not limited to top-shelf administration. It has it's valid application in smaller departments and sections as well. We can find more engineering man-hours at home.

TO MAKE IT SELL FASTER...

consider a ball

Again and again, the buying public has demonstrated—with cash on the line—that it has a strong and ready preference for *any* product that features one or more balls in its mechanism. Ball-point pens, for example . . .

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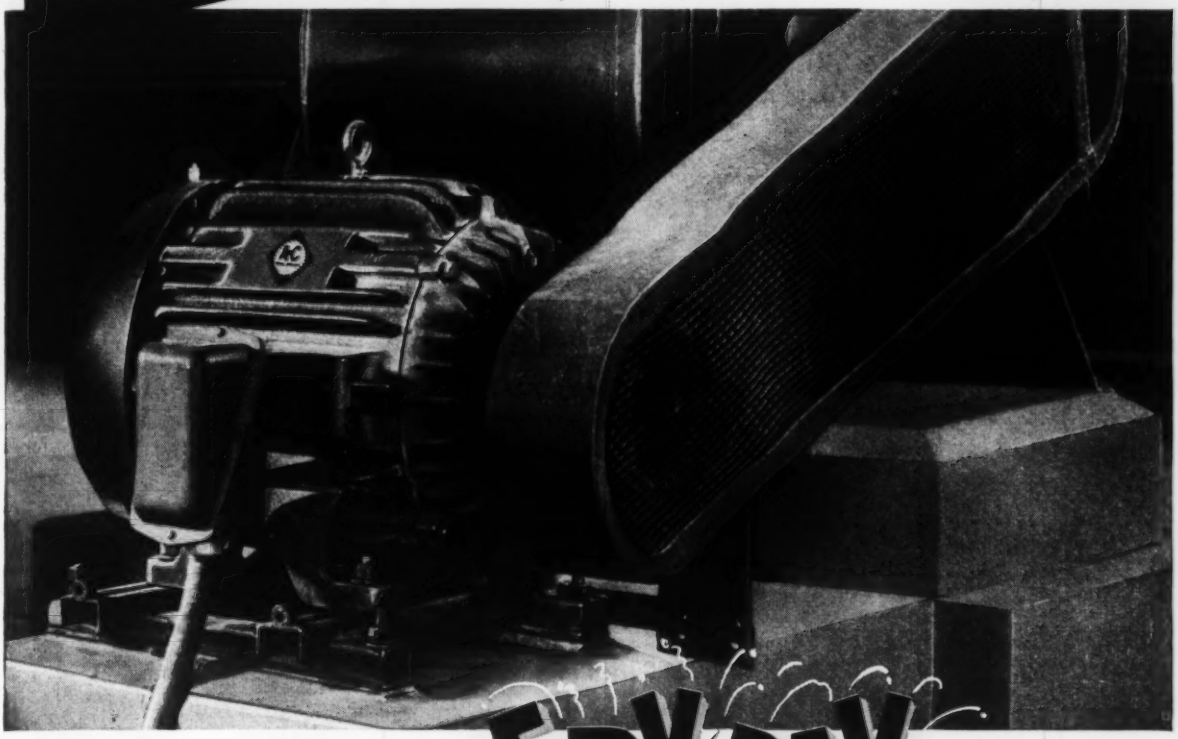
—ITEM 259—

For More Information Circle Item Number on Yellow Card—page 19

There's **MORE** Cooling Surface in these deep-ribbed **MOTORS**



No Day is FRY DAY

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● Frying of insulation is impossible under normal conditions with the extra-large cooling surface of Allis-Chalmers rib-type TEFC motors. The result—you expect and get longer motor life.

The engineered partner of A-C motors is Allis-Chalmers control.

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As a new machinery component or as replacement, specify Allis-Chalmers. Discuss your particular application with your nearby A-C distributor, A-C district office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

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A-C ALLIS-CHALMERS

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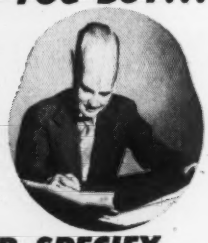
—ITEM 260—

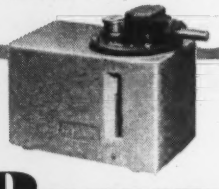
WHETHER YOU BUY...



OR SPECIFY...

This Unit Is The Answer To

- *production waste*
- *design problems*
- *fire risk*
- *excessive repair bills*



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AUTOMATIC LUBRICATION

Automatic lubrication is one thing that designers, plant engineers and production men insist on these days —for their own machinery . . . and the equipment they manufacture. And careful purchasers make sure the automatic lubrication systems they buy are *Bijur Systems.*

For nothing protects like Bijur. Bijur Systems save production time and repair bills . . . reduce down-time and fire risk . . . lengthen machine life . . . and eliminate product spoilage due to over-lubrication. Bearings are never thirsty for oil, never flooded.

That's why it's just good business to have a custom-engineered Bijur System on the equipment you own, and *design* one into the equipment you manufacture. Installation is easy, cost is minimal, savings are substantial. Write today for *all* the facts about Bijur Systems! 1836

P-3

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Rochelle Park, New Jersey
Pioneers in Automatic Lubrication

—ITEM 261—

New Machines

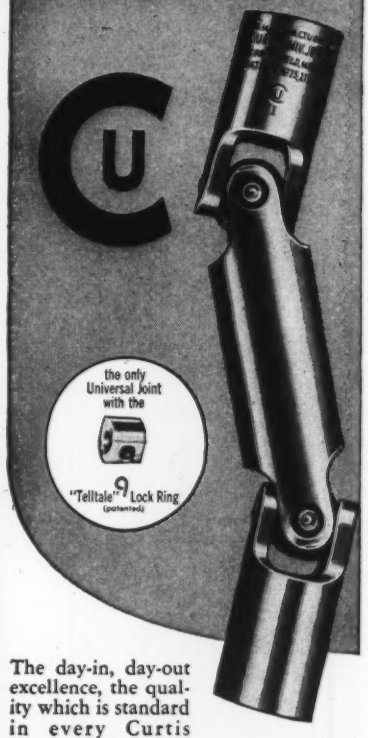
Materials Handling

Vibrating Feeder: Velofeeder provides continuous feeding of loose bulk material into processing machinery. The machine will handle up to 50,000 lb per hour of hard materials and 30,000 lb of soft materials. Standard tray width is 16 in. Feed rate is variable to 50 fpm; angle of feed, 5 deg down from horizontal. Uphill feed is possible at somewhat decreased output. The motor is ⅛-hp; an explosionproof motor is available for installation where dust conditions are a hazard. Operating frequency is 1850 vibrations per minute. The unit requires floor space of 35 x 16 in., and is 19 in. high. *Richardson Scale Co., Clifton, N. J.*

Fork Truck: Cargo-Scout truck handles loads in confined areas at high speeds. Short wheelbase and 360-deg steering permit maneuvering in narrow aisles and inside truck trailers and box cars. Design prevents steering wheel kick-back. Stand-up end control allows the operator to get on and off the truck frequently. The truck has a 3000-lb capacity at 24 in. on a 68 in. high model, and at 20 in. on an 83 in. high model. Design also incorporates a worm drive, contactor controls and caster type trail axle. *Elwell-Parker Electric Co., Cleveland.*

Hoist Trolley: Series 700 Load Lifter motor-driven, single-speed unit is designed for installation on electrically powered hoists having capacities from 1000 to 12,000 lb. It is available with traverse speed ranging from 25 to 130 fpm, depending on size and voltage requirements. Drive wheels have integrally cut, heat-treated, spur geared teeth. All models are adjustable to fit a wide range of I-beams. The driving mechanism consists of a 30-minute rated squirrel cage and face-mounted, totally enclosed motor. Sealed-in worm drive unit is permanently lubricated. Four-button, 24-v control

Standard Quality sets Quality Standards



The day-in, day-out excellence, the quality which is standard in every Curtis Universal Joint, has made the Curtis Joint the quality standard of the industry.

Each Curtis Universal Joint component is made from specially selected steel, individually heat-treated for a specific purpose. This accounts for the long life and dependable performance of Curtis Universal Joints.

CURTIS UNIVERSAL JOINTS

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—ITEM 262—

station is magnetically interlocked. Cushion start, by means of adjustable ballast resistors, is available on the larger capacity trolleys for smooth acceleration. *Manning, Maxwell & Moore Inc., Shaw-Box Crane & Hoist Div., Muskegon, Mich.*

Metalworking

Multiple Point Presses: Six types of multiple point enclosed presses, having a capacity range from 200 to 2500 tons, are designed to produce large stampings such as automobile roofs and refrigerator doors. The six basic types, each available in several capacities, are: Two and four-point single action; two and four-point double action; four-point single action underdrive; and four-point triple action underdrive. The machines have integral gear and eccentric units, motorized slide and blankholders, built-in die area lights, flush-mounted air and electrical controls for operation of auxiliary equipment, automatic lubrication, and high-speed pneumatic friction clutches. Specifications of the presses meet JIC standards. *E. W. Bliss Co., Canton, O.*

Cut-off Saw: Sixteen-inch blade capacity saw cuts ferrous and nonferrous materials of various sizes with minimum burr. Swivel cutting head and material clamp permit cutting at angles up to 45 deg with material positioned as for a straight cut. Equipped for wet cutting, the saw can also be used dry. An adapter sets the cutting head to one side for cutting gates and risers from large castings. The saw is driven by a 5-hp motor. Complete line of blades is available. *Victor Engineering Corp., Paoli, Pa.*

Drilling Machine: Redesigned turret drill performs up to six different, consecutive drilling and tapping operations in any sequence with one handling of the work. Spindle speeds, depths and reversals for tapping are preset for each spindle and repeat automatically as the turret is indexed during successive operating cycles. Spindle speed range is from 200 to 4000 rpm, variable on each spindle. Dual-speed motor is rated 1-hp, 1800 or 900 rpm, 220 or 440 v, 60 cycle,

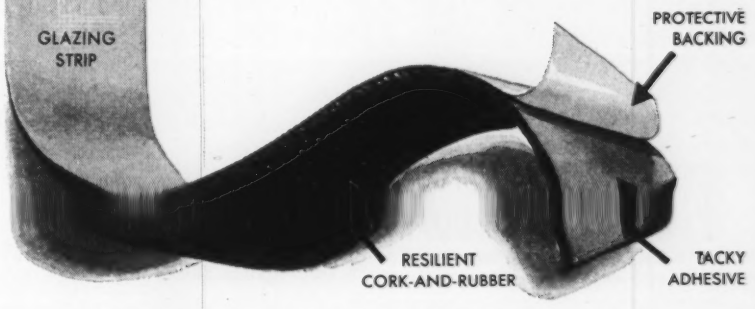
VIBRATION-DAMPING
SHOCK-ABSORBING
SKID-PROOFING
CUSHIONING
NOISE-KILLING
SCRATCH-PREVENTION
GLAZING STRIP

WEATHERPROOFING

Armstrong DK-153 Tape makes an effective gasketing material for many applications. In this parking meter, for example, it's used between the glass face and metal housing to seal out rain, dust, and dirt. This resilient cork-and-rubber material acts as a cushion, too—soaks up shocks, helps prevent glass breakage.

DK-153 is easy to apply. Just peel off the protective cloth backing and press the tape into place. Its tacky adhesive coating sticks tightly to any clean, dry surface.

You can get DK-153 in a variety of widths and thicknesses . . . in sheets, rolls, die-cut shapes. For samples, write on your letterhead to Armstrong Cork Company, Industrial Division, 7303 Dean St., Lancaster, Pennsylvania.



Armstrong DK-153 TAPE

. . . used wherever performance counts

—ITEM 263—

AMERICAN CRUCIBLE knows Bearings!

Send Prints for Quotation

When you are looking for bearings, bushings and wearing parts that will stay on the job and give trouble-free service—SWITCH TO

Promet Engineered Bronze

GET THE GOOD, SOUND QUALITY THAT ASSURES EXCELLENT PERFORMANCE

Discuss your bearing problems with our metallurgists, engineers, and laboratory technicians. This service will in no way obligate you. Write for free literature and service data sheets or send blueprints, conditions of operation and data for recommendations and quotations.

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Please send free literature and service data sheets on Promet Bronze.

NAME_____

COMPANY_____

STREET_____

CITY & STATE_____

—ITEM 264—

New Machines

three phase. Table work surface is 22 x 24 in. Vertical table travel is 18 in.; vertical head travel, 12 in. The unit requires floor space of 34 x 50 in. *Howe & Fant Inc., East Norwalk, Conn.*

Double Crank Presses: Line of straight-side presses is available in high-speed, blanking flywheel types with adjustable-speed drives up to 300 strokes per minute, or back-geared types for drawing, forming, punching or piercing operations. Six capacities from 30 to 150 tons are offered. The machines have box type rams, tie rod construction, automatic lubrication, air clutch, air-actuated spring set brake, rotary limit switch and electrical controls. *Johnson Machine & Press Corp., Elkhart, Ind.*

Lapping Machine: Six-inch bench type cylindrical lapping unit provides microinch finishing to 1 rms or less on parts such as plug gages, tapered plugs and pins, cylindrical pieces and other parts up to 6 in. in diameter. Design incorporates vented rollers, self-aligning ball bearing pillow block, oilless bearings and four-speed interchangeable pulley drive. *Spitfire Tool Co., Chicago.*

Portable Tools

Vertical Sander: Model 201 light vertical sander is designed for use with soft, resilient back-up pads and abrasive disks. Thumb-operated throttle provides three positive speed settings. Lever throttle handle for feathering finger control is also available. Air consumption at maximum horsepower is 31 cfm; stall torque, 5.2 ft-lb. Motor is fully contained within a cylinder body sleeve. Weight of the sander is 5 lb. *Master Pneumatic Tool Co. Inc., Bedford, O.*

Cup Wheel Grinder: Model 2000 Series 6-in. pneumatic cup wheel grinder design incorporates a magnesium housing and a redesigned rotor which reduce weight of the unit to 10½ lb, without guard. The rotor, which floats on the shaft, is ground alloy steel. The air port leads under the rotor blades to provide positive starting. The grinder has a three-position dead handle. The snap handle is fingertip-controlled. Either a straight type abra-

The abbot and the "Popping Plugs"

The *abbot* re-read the note, "Electronic Computer Manufacturer "X" is having trouble keeping plugs from popping out of jacks. Complex servo-mechanisms and controls are being thrown out of whack as a result. Sound interesting?"

The abbot's Solution: Use an Abbott bearing ball as a spring-loaded detent ball to hold the plug securely in its receptacle. Result: 20 lbs. pull needed to remove it, *and* an end to the problem of the "popping plugs."

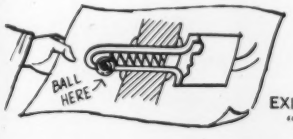


EXHIBIT "A"

Abbott carbon steel bearing balls serve many needs because they are Deep Hardened and Tempered. This makes them perform efficiently under high load factors and gives them increased shock resistance. These qualities amply justify the name . . . ABBOTT – "the Ball with the Armored Heart."

Want to learn more about the little man – and how he can help you? Drop a line to . . .

ABBOTT

The ABBOTT BALL Company

50 Railroad Place, Hartford 10, Conn.

—ITEM 265—

With KELLER AIR MOTORS you get...

GREATER POWER with less weight

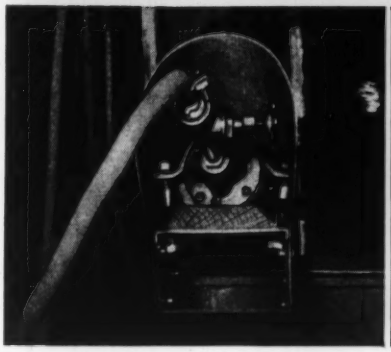
SMALLER SIZE for compact design

PROTECTION against overload

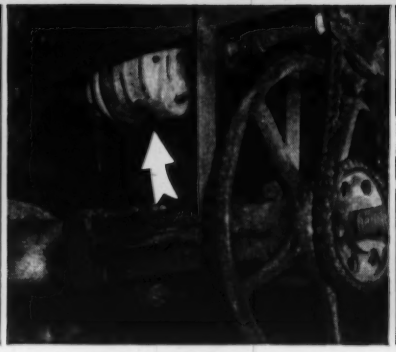
SAFETY in hazardous locations

KELLER PISTON-TYPE AIR MOTORS are engineered to afford maximum power in small units . . . with a high power-to-weight ratio. Reversible operation and infinitely variable speed (from zero to full rating) provide complete control. Keller Air Motors cannot "burn out" from overload, and they are nonsparking for safety.

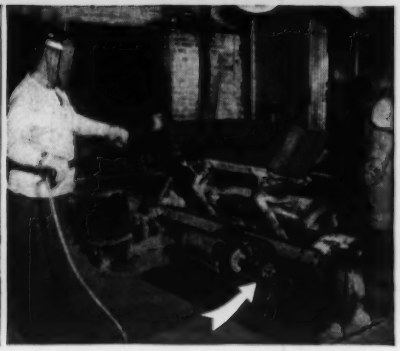
WRITE FOR CATALOG SECTION NO. 70 for detailed information



Keller Air Motor used to drive the impeller for agitating enamel in a dip tank.



This air motor operates a 14" valve in an oil refinery where safety is a must.



Keller Air Motors power tilt-turn-table for enameling red-hot bathroom fixtures.

GARDNER-DENVER

KELLER TOOL division, Grand Haven, Michigan

THE QUALITY LEADER IN COMPRESSORS, PUMPS, ROCK DRILLS AND AIR TOOLS FOR CONSTRUCTION, MINING, PETROLEUM AND GENERAL INDUSTRY

—ITEM 266—

sive wheel or flanged cup type can be used with the unit. A silencer insert reduces noise level. *Reed Roller Bit Co., Cleco Air Tools Div., Houston, Tex.*

Drill Motor: Portable Spacematic air-powered hand tool drills and countersinks close tolerance holes in one operation. Changeable spacing feet assure holes drilled to accurate spacing. Holes ¼-in. in diameter, with ½-in. diam countersink, can be drilled in 5 seconds through ¾-in. 75 ST aluminum alloy. Adjustments are provided for rate of drill feed and for drill countersink depth. Close reamer holes can be drilled without subsequent reaming operation. *Winslow Product Engineering Corp., Arcadia, Calif.*

Processing

Injection Molder: Model 800-H-48 plastics injection molding machine with 48-oz polystyrene capacity has an injection speed of 2410 cu in. of material per minute. Injection unit is mounted on ways and actuated by a hydraulic cylinder. Dual pump permits two-speed injection and dual-pressure injection. Straight-line, hydraulic mold clamp makes possible rapid closing and opening speeds with automatic, adjustable slow-down prior to mold contact, at mold breakaway and during ejection of parts. Plasticizing chamber is equipped with three individually pyrometer-controlled heat zones. Heating chamber can be removed for cleaning. Areas of platen and die head accommodate large molds. Thin molds can be used without bolsters. Mold mounting area is 36 x 54 in.; mold clamp stroke is 35 in. Stroke adjustments are made at the front of the machine. All hydraulic components are easily accessible. *Hydraulic Press Mfg. Co., Mount Gilead, O.*

Fluxless Solderer: Sonobond Model S-5-H-55-10 large hand model unit is designed for heavy duty industrial use in soldering or coating copper, aluminum, brass, silver or magnesium. Ultrasonic soldering head is equipped with a ⅝-in. diam soldering tip and will accommodate a variety of tips up to the ⅝-in. diam size. Driven by a 110 w ultrasonic generator, the head is air-cooled for continuous operation. Unit includes the soldering head with 70-w tip heater, generator and a heating platen with a capacity of 1200 w. *Aeroprojects Inc., West Chester, Pa.*

Testing and Inspection

Plano-Interferometers: Line of surface flatness inspectors provides accuracy of inspection to 0.0000005-in. Work being tested does not come into contact with the optical flat. Plano-interferometers are available in vertical and horizontal types for inspection of different shaped objects. The vertical unit checks objects up to 3 in. thick and 8 in. long. Working aperture is 5 in. Horizontal interferometer checks objects to 6 in. thick. Model D-308 has a 6½ x 6¾ in. work table and 2½ in. working aperture. Larger models are available with 8 x 8 in. work table and working aperture size of 5 in. *Davidson Manufacturing Co., West Covina, Calif.*

Optical Comparator: Model P-5 duplex optical comparator is used as an upright floor model for vertical projection operations or can be bench-mounted in a horizontal position. Condensers employed and lamp housing provide high intensity parallel light. Precision ground steel stage provides a large work area for mounting of parts or holding fixtures. Image screen is 14 in. in diameter. Six lenses providing magnifications from 10 to 100X are available as standard. Right angle universal measuring stage is available as an accessory. *Portman Instrument Co. Inc., New Rochelle, N. Y.*

Heat Distortion Tester: Five similar or different specimens can be tested simultaneously by a five-gang tester. Each of the five units, complete within itself, is composed of an automatic deformation indicator, thermometer, pilot light, automatic heating controls and cooling system. Temperature increases can be obtained from 25 C at a rate of 2 C per minute. Specimens from ⅛ x ½-in. to ½ x ½-in. are accommodated by each unit of the tester. Fiber stress of 66 or 264 psi can be applied to samples subjected to center loading transverse stress. *Tinius Olsen Testing Machine Co., Willow Grove, Pa.*

LOWER COSTS
IN THE
SHORT RUNS
WITH
PRE-TOOLED rotor and stator LAMINATIONS

You can cut development costs on rotating electrical gear with Lamco's help.

Thousands of interchangeable dies permit limitless combinations to produce almost any pattern — quickly, and without special tooling costs. In addition to the facilities of Europe's largest makers of electrical stampings, our own rich experience in the engineering and production of electric motors is at your service.

Send us your drawings and specs. Glad to quote, without obligation, on laminations exactly as you detail them — and alternatively on time- and cost-saving pre-tooled equivalents.
A Catalog will be ready about 1 March 1956.

COMPANY
Box 13
300 Main Street
Stamford, Conn.
Fireside 8-7013

—ITEM 267—
For More Information Circle Item Number on Yellow Card—page 19

Feed Screws

Jack Screws

Lead Screws

Return Screws

Metering Screws

Power Screws

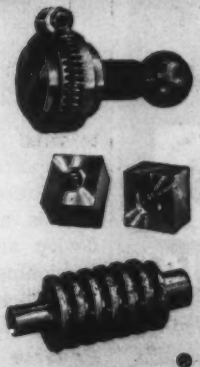
Elevating Screws

SCREWS

any type... any size... any quantity!

Square threads, acme threads, buttress threads, V-threads, ground threads —one screw, or ten thousand or more— whatever you need, *you can get it at Illinois Gear!*

If you want highest quality and precision, plus on-time delivery (even if we have to work around-the-clock to meet your emergencies), then send your next order to Illinois Gear!



Look for this mark (ILLG) *... the symbol on finer gears*

ILLINOIS GEARS Reg U.S. Pat Off

Gears for Every Purpose ... one gear or 10,000 or more

ILLINOIS GEAR & MACHINE COMPANY

2108 NORTH NATCHEZ AVENUE • CHICAGO 35, ILLINOIS

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flat springs
INTO YOUR PRODUCT?

Check Sandsteel for a wide variety of precision springs made to your specifications for top performance and accuracy in your equipment.

Sandsteel design facilities—that have made us "America's Headquarters for Mainsprings" for over a quarter century—are at your service.

Only Sandsteel makes DUAL POWER "cross-curved" mainsprings for longer lasting, smoother power delivery.

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Instruments
Motion Picture Cameras
Recording Devices
Earphones
Eyeloupes
Reels (return mechanism)
Television Aerials
Instruments
Vending Machines
Toys

NEW Sandsteel's 20 page illustrated mainspring guide to better product design and performance . . . authoritative information on applications for flat springs . . . available to manufacturers and design engineers without obligation.

AMERICA'S HEADQUARTERS FOR MAINSPRINGS

SANDSTEEL SPRING DIVISION

Sandvik Steel, Inc., Fair Lawn, N. J.

Sandvik Steel, Inc., Dept. 30
Fair Lawn, N. J.
Gentlemen:
Kindly send, without obligation, a copy of "Sandsteel Springs for Dual Power"
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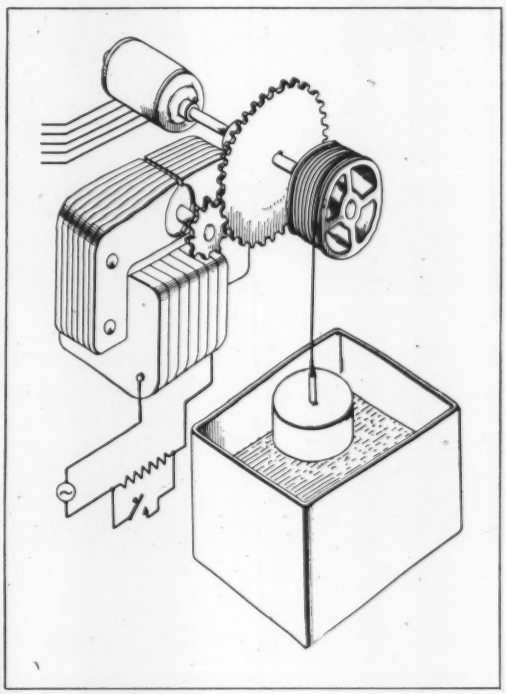
POSITION _____
FIRM NAME _____
FIRM ADDRESS _____
CITY _____ ZONE _____ STATE _____

—ITEM 269—
For More Information Circle Item Number on Yellow Card—page 19

NOTEWORTHY Patents

Automatic Tension Control

Tension can be maintained in wire or other flexible materials by utilizing an electric motor whose torque has been reduced. In this system, the motor exerts just enough torque to wind the flexible material on a drum when tension is released. With proper adjustment, the motor will permit the material to be unwound without excessive drag. A resistor used to reduce voltage to the exciting winding of the motor may be shunted out when full torque is desired



to wind the material on the drum. A synchronous transmitter may be coupled to the drum shaft for applications where monitoring of angular shaft position is necessary. Among the applications of the device are liquid level monitoring, wire or thread tensioning. *Patent* 2,708,256 *assigned to Bendix Aviation Corp. by R. B. Colt.*

Reverse Rotation Brake

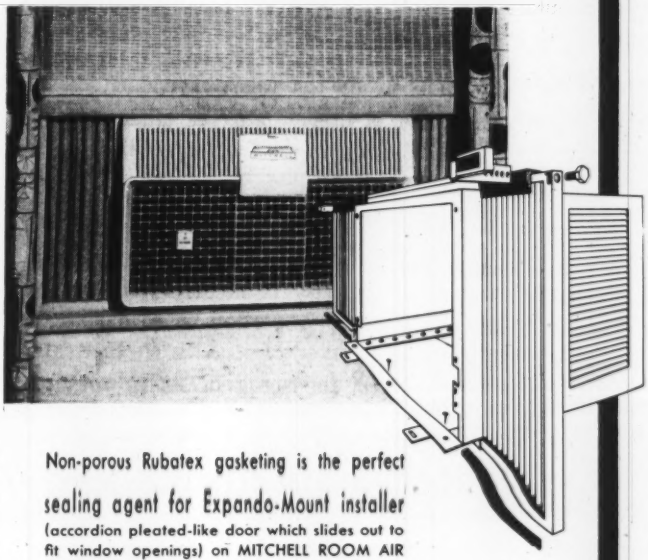
Back-up prevention device for power-screw drive units uses two "planet" pinions arranged to rotate around a stationary sun gear. Power is transmitted to the pinion arms by a T-shaped arm on the drive shaft. Angular position of the pinions is maintained by finger-like members, rigidly mounted to the driven shaft at a fixed angle, which engage the pinion arms. During normal operation, motion of the T-shaped arm keeps the pinions at the maximum angle of separa-

doing unusual jobs unusually well

for 20 years

Layers of Rubatex assure tight effective seal between metal pylon and metal wing surface of CHANCE VOUGHT'S F7U-3 CUTLASS. Also valuable for streamlining purposes and cushions the two metals when pylon is attached to wing of jet fighter.

Rubatex gives air, dust and moisture a technical shut out as an effective non-corrosive seal around door and glass of new U. S. GAUGE PRESSURE PILOT. Dribak adhesive on smooth surface of Rubatex makes application easy and sure.



Non-porous Rubatex gasketing is the perfect sealing agent for Expando-Mount installer (accordion pleated-like door which slides out to fit window openings) on MITCHELL ROOM AIR CONDITIONERS. Insures complete, durable, air-tight, water-tight, dust-tight installation for life of air conditioner.

better performance cheaper

Nitrogen plus natural resiliency of rubber team up in Rubatex to recover quicker than other soft rubber materials after being compressed and to keep coming back for a longer time. Unique closed cellular structure shuts out oxygen, heat, cold, moisture and dirt even at cut edges—eliminates expense for special coating or molded-on skin. No restriction as to shape or size. Can be die cut or stripped. Easily cemented to other materials. Available in soft, medium and firm grades in varying densities and thickness. Write and let us tell you how you can get better gasketing, sealing and cushioning performance cheaper with Rubatex.

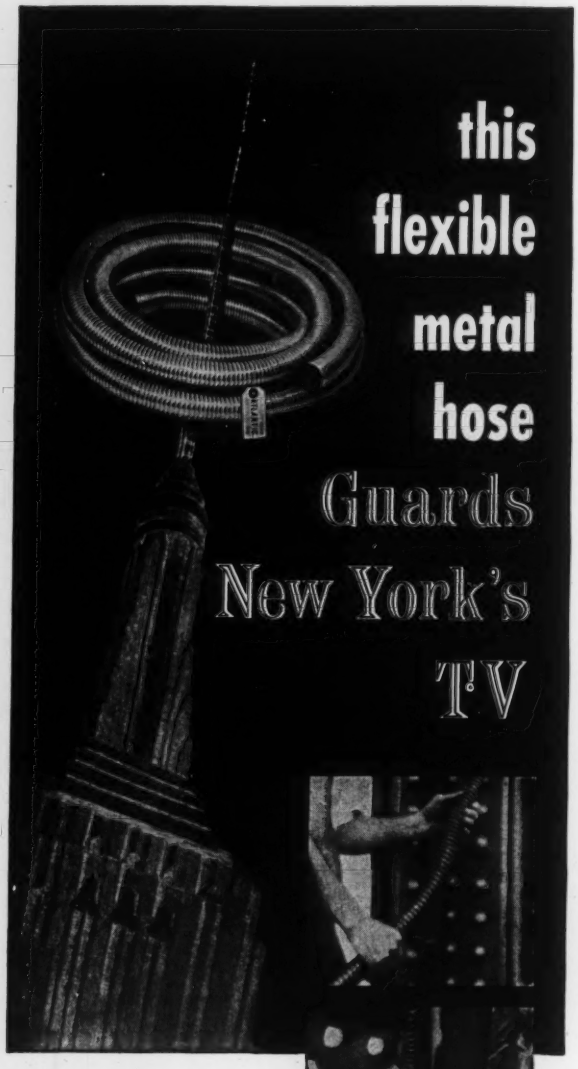
PIONEER MANUFACTURER OF CLOSED CELLULAR RUBBER

also manufacturers of:

Rubatex Closed Cellular Vinyl
Rubatex Insulation Hardboard
Rubatex-Crepe
Rubatex Soffee-Crepe
Rubatex Vinyl Foam
Rubatex Plastic Seine Floats

GREAT AMERICAN INDUSTRIES, INC.
RUBATEX DIVISION, Bedford, Virginia

G.A.I. RUBATEX



—another example of how Atlantic's engineers and ingenuity devise new solutions to new problems.

The $1,000,000 tower atop the Empire State building was designed to usher in a new era in TV transmission and reception. Its construction required an unprecedented number of circuits to travel up a tower often of less than two feet square. The conduit, enclosing the cables, had to be extremely *flexible* to avoid splice plates, rivet heads and diagonal braces in the steel work. It had to be permanently weather tight.

Ordinary rigid and flexible metal conduit failed! Atlantic's engineers in cooperation with the RCA Service Co. designed a heavy duty, high pressure bronze hose that did the job and also saved many costly and hazardous man hours of work. This hose was JOB TESTED and CERTIFIED.

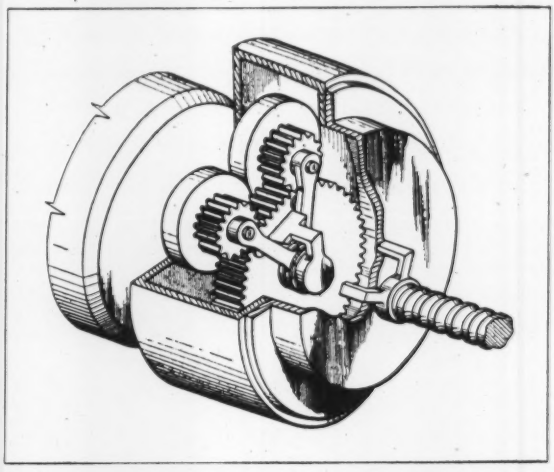
Our engineers will help solve *your* problems in weather protection . . . flexibility . . . conveying . . . controlling pressure, movement and vibration . . . correcting misalignments. Seamless and Interlocking Hose. Bronze, Steel, Stainless Steel, Monel. ⅛"-36" I.D. with proper fittings. Write for Bulletin #500. See our Catalog in Sweet's Product Design File.

ATLANTIC METAL HOSE CO., Inc.
318 DYCKMAN STREET, NEW YORK 34, N.Y.

—ITEM 271—

Noteworthy Patents

tion. Under reverse rotation, however, motion of the finger members tends to drive the pinion arms together, engaging rubber disks mounted to each pinion to provide a braking action. When normal power flow resumes, the disks disengage, freeing the gears to resume normal rotation. *Patent 2,710,085 assigned to Cleveland Pneumatic Tool Co. by R. N. Jungles.*

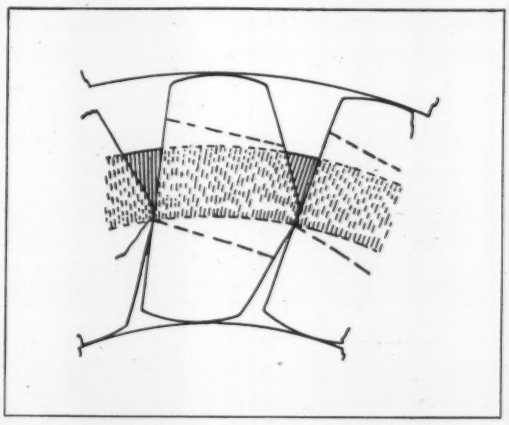


Rubber Vane Pump

Fluid pressure is developed in a rotary pump by rubber vanes on a hub mounted eccentric to the housing. As the impeller rotates, the vanes squeeze the fluid into the outlet port in the narrow portion of the fluid chamber. As the vanes expand on the return cycle, fluid is drawn into the pump housing. *Patent 2,712,792 assigned to Scott-Atwater Mfg. Co. by M. F. Snyder.*

Sprag Clutch

Disengagement of a one-way clutch at a predetermined angular velocity is accomplished by specially designed sprags. A portion of each sprag is cut away, shifting center of gravity so that, at a predetermined speed, the sprag pivots to withdraw from frictional contact with the inner race. Shape of the cut-out portion can be varied to permit the sprags to disengage at different rotational speeds. *Patent 2,711,238 assigned to Formsprag Co. by L. T. Szady.*



For More Information Circle Item Number on Yellow Card—page 19

DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS

SILICONE LAMINATED PANEL BOARD IMPROVES ELECTRONIC DEVICES

Based on laboratory and field testing, Schlumberger Well Surveying Corporation now uses a silicone-glass laminate instead of bonded mica sheeting and phenolic laminates as the panel board material in many of their electronic oil well surveying instruments. Here are some of the reasons for this selection.

Schlumberger found that the silicone laminate has more uniform dielectric proper-

ties than either mica bonded sheeting or phenolic laminates. Its stability at oil well temperatures is comparable to that of the mica sheetings. Furthermore, the silicone laminate is not subject to cold flow around the high pressure split rivets used to fasten panel board in instruments; it does not loosen in service as do phenolic or bonded mica panel boards. The silicone laminate is also easier, faster and less expensive to install than the fragile mica sheet.

Another important factor in the selection of silicone laminates is their greater moisture resistance. Moisture absorption of silicone laminate is only 0.02% compared with 2% for the phenolic.

To increase moisture resistance still further, Schlumberger coats all joints and connections in their instruments with a waterproof Dow Corning silicone compound. Applied during both original assembly and field maintenance, this heat-stable compound remains in place at temperatures from —70 to 400 F and protects electronic equipment against moisture and electrical leakage. *No. 72*

Now Available—The 1956 Reference Guide to Dow Corning Silicone Products. A concise, comprehensive, 12 page reference that is convenient-to-use. It's packed with data, properties, and information on how you can use silicones in designing new equipment, improving performance and reliability of original equipment, or reducing production and maintenance costs. *No. 73*

ELECTRIC WHEELS IN HUGE "SNO-FREIGHTER" POWERED BY SILICONE INSULATED MOTORS

The many advantages of placing the power unit close to the work are being realized through the use of heat-stable Class H electrical insulation made with Dow Corning Silicones. A recent example is the silicone insulated motor in each of the electric wheels on the giant "Sno-Freighter" built by R. G. LeTourneau, Inc. of Longview, Texas.

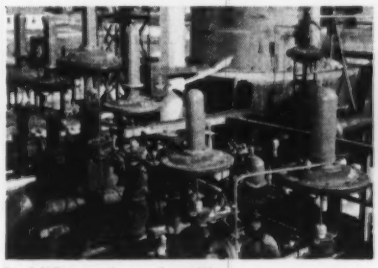
Long-time leader in the development of huge rubber-tired tractive equipment for construction and military use, LeTourneau built this 274 ft. over-land train to provide winter-time freight service between isolated sections of Alaska. Designed and built in only six weeks, the train has a load capacity of 125 tons. Its enormous tires distribute weight broadly so the entire train maintains positive traction on frozen rivers and bays, up icy grades and across rough Arctic terrain.

Each of the 24 wheels on the "Sno-Freighter" is individually driven by a silicone insulated d-c motor located in the tubular axle, and connected to a gear train in the wheel hub. Silicone insulation was specified to give maximum power per pound and reliability under adverse operating conditions. *No. 75*

SILICONE VALVE LUBRICANT SEALS, PREVENTS CORROSION

In the process industries including refineries, petrochemical and plastic manufacturing plants, Dow Corning Valve Seal A improves the performance and increases the life of valves handling a variety of corrosive chemicals and gases. Effective at temperatures from —40 to 500 F and highly resistant to many chemicals, this silicone lubricant provides a durable seal against leakage of process fluids, and protects valve stems against corrosion.

In fact, Dow Corning Valve Seal A has proved so dependable in such service that Foxboro Valve engineers now offer their Stabilflo line equipped with an isolating valve and lubricator for injecting the silicone lubricant. Excellent results, particularly in reduced maintenance, have been obtained with silicone lubricated



Stabilflo valves handling steam, water, oxygen, gasoline, light hydrocarbons, natural gas, chlorine, hydrochloric acid, cold sulfuric and nitric acids, and ammonia. Trial samples of Dow Corning Valve Seal A are available from any Dow Corning office. *No. 74*

Design Edition 18

DOW CORNING CORPORATION - Dept. 6803
Midland, Michigan

Please send me 72 73 74 75

NAME _____

TITLE _____

COMPANY _____

STREET _____

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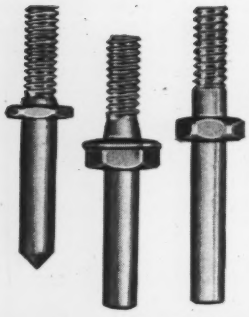
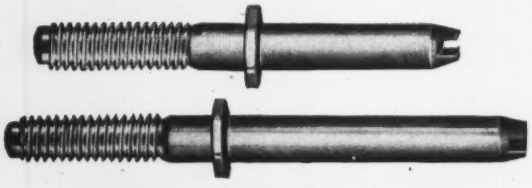
ATLANTA • CHICAGO • CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEW YORK • WASHINGTON, D. C. (Silver Spring, Md.)

Canada: Dow Corning Silicones Ltd., Toronto; **Great Britain:** Midland Silicones Ltd., London; **France:** St. Gobain, Paris



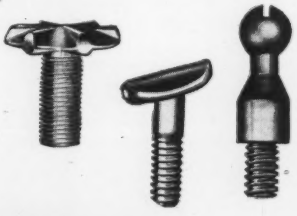
ELECTRICAL CONTACTS



ADJUSTING SCREWS

NOTE: LEFT-HAND THREADS

SPECIAL SHAPES



ELCO

COLD-HEADED PRODUCTS

One interesting feature of several of the items above is that they are roll-threaded on the *short* end — a neat trick that called out some ingenuity on the part of ELCO shop people. ELCO facilities also include an Engineering Service that will help you design — or re-design — your special screws and similar pieces for *lowest-cost* manufacture. *Always consult your ELCO representative.*

COMPLETE LINE OF ELCO PRODUCTS

- WOOD SCREWS
- MACHINE SCREWS
- MACHINE SCREW NUTS
- TAPPING SCREWS
- SPECIAL SCREWS
- THREAD-CUTTING SCREWS
- PHILLIPS AND SEMS SCREWS
- COLD HEADED PRODUCTS
- PIPE PLUGS
- STOVE BOLTS
- CAP SCREWS
- LAG SCREWS
- DRIVE SCREWS

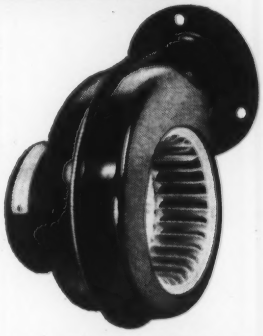
"ELCO SCREWS ARE GOOD SCREWS... ASK A MAN WHO HAS USED THEM"

ELCO TOOL AND SCREW CORPORATION

1950 BROADWAY, ROCKFORD, ILLINOIS

—ITEM 273—

HEINZE BLOWERS



ZSS

The Most Compact 50 CFM Blowers Available Today.

The Heinze sturdy, low speed type "Z" shaded pole induction motor provides quiet, trouble-free operation.

A 3⅝" Torrington balanced air rotor, with slow speed, minimizes air noises.
Operating speed, 1650 RPM (free air)
Draws 40 watts on 115v, 60 cycles (230 volts supplied if desired)
Can be equipped with L type or Flat Strap brackets in place of flange outlet normally furnished.

Heinze Electric Co

685 Lawrence Street, LOWELL, MASS

—ITEM 274—

If GEARS Are YOUR Problem

We Can...

- act as your precision gear department
- keep your production line going smoothly without shut-downs
- reduce rejects, hand adjustments or other supervisory attention
- provide you with precise gearing for any purpose whatever
- and do it with a strict adherence to safe engineering economy

SPECIALISTS IN THE FINE PITCH FIELD

Use our more than a decade of experience in Gear making, in any material, for America's most particular users of precision or commercial gears. Send blueprints or specs for prompt estimates to

PG

PROCESS GEAR CO., INC.

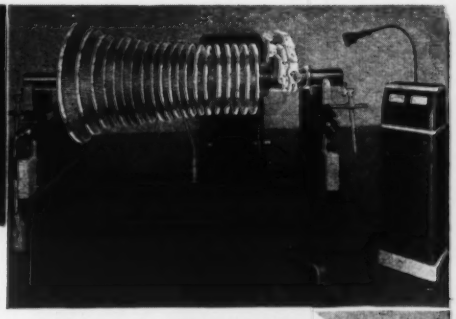
4608 W. Fullerton Ave. • Chicago 39, Illinois

—ITEM 275—

For More Information Circle Item Number on Yellow Card—page 19

4 OUT OF 5

VIBRATION PROBLEMS ORIGINATE WITH UNBALANCE



NOW Save up to 50%* of your balancer investment ... Eliminate Dynamic and Kinetic unbalance ... with a STEWART-WARNER ELECTRONIC INDUSTRIAL BALANCER

CRADLE and PORTABLE MODELS available

IN PRODUCTION...greatly reduce your manufacturing costs by eliminating rejects caused by rotor unbalance.

FOR MAINTENANCE...reduce your maintenance expense by eliminating down time situations requiring replacement of bearings and shafts, labor, etc., in addition to production loss. Instrumentation will also measure areodynamic vibration factors.

STEWART-WARNER electronic industrial balancers are sturdy, compact, extremely accurate and engineered for years of trouble-free service.

Extreme maximum and minimum ranges are engineered into every STEWART-WARNER ELECTRONIC INDUSTRIAL BALANCER. Other makes require more than one machine to attain these capacities.

Stewart-Warner Electronic Industrial Balancers are manufactured and distributed by:

Check These Stewart-Warner Established Capacities:

- ½ lb. to 25,000 lb. weight range
- ½" to over 96" diametral capacity
- .03 in.²-oz. Dynamic sensitivity
- Convenient friction belt drive requires no adaptors and eliminates belt wrap-around problems
- Less than 2 minutes set-up time without supervision

From $3795 including operator training

- 4½" to over 144" length range
- .01 in.-oz. Kinetic sensitivity
- Operating safeguards

The above capacities are established. Should your requirements exceed the above, please write us stating your exact balancing problem.

*No other industrial balancer incorporates so many advanced features, yet the Stewart-Warner sells at approximately 50% less than other advertised industrial balancers.

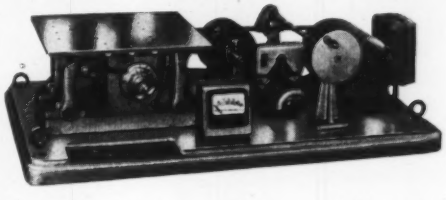
MERRILL *engineering laboratories*

Write now for FREE brochures with complete information

"Industrial Electronic Balance Specialists since 1935" • DEPT. SJ • 1240 LINCOLN STREET • DENVER 3, COLORADO

—ITEM 276—

Range Selector Is Highlight Of All American Model 100 HLA-D Vibration Fatigue Test Machine



This machine subjects parts or assemblies, up to 100 lbs. in weight, to a comprehensive vibration fatigue test. It has a 50% overload safety factor. Vibration in simple harmonic motion is produced horizontally. Displacement (double amplitude) is adjustable from 0" to 125". Automatic Range Selector controls acceleration and deceleration. From 10 cycles per second frequency may be increased uniformly to 60 c.ps. and then decreased to 10 c.p.s. Any desired range within the total may be selected. Selector can be switched off and frequency held at any c.p.s.

Recommended for testing electronic, electrical, mechanical or optical parts. One of 7 models. Send for Catalog F, containing helpful data, nomograph chart and listing typical users. Write to

ALL AMERICAN TOOL & MFG. CO

8023 LAWNDALE AVENUE, SKOKIE, ILLINOIS

Makers of All American Precision Die Filing Machines.

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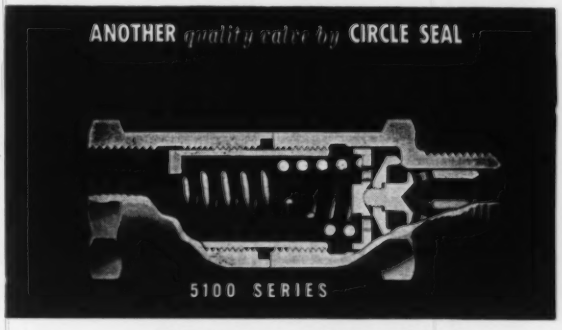

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A RELIEF VALVE THAT DOESN'T LEAK!

- In-line design
- Adjustability that can't be tampered with
- Excellent flow characteristics
- Precise operating reliability
- Suitable for almost any gas or liquid

Send for information today..... ☐

CIRCLE SEAL *precision valves*

Representatives in Principal Cities.

JAMES•POND•CLARK

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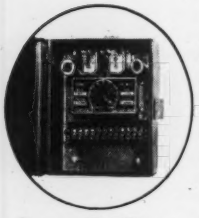

Ferrara T-1 Timer

LOW COST TIMING FLEXIBILITY

Whatever your timing problems, there's a standard or special Ferrara timer, backed by extensive use, that can meet your need—dependably and economically.

Prices start at $40.00 for open style panel mounted timers. For single cycle, repeat cycle, interval, delayed timing, on-off, multi-cycle.

Standard accuracies better than 1% available. Supplied in timer ranges as low as 20 milliseconds and up, with high dial set accuracy, direct reading dials, special enclosures and other optional features.

ferrara ELECTRONIC TIMERS

See your distributor or get the whole story in free catalog.

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8106 W. NINE MILE RD.
OAK PARK 37, MICH.

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CHECK *Abart* FOR ALL SPEED REDUCTION NEEDS!

Write for pocket-size Abart Catalog

Compact, Efficient, Long-Life Units . . . more than 75 models available. Ratings from 1/50 to 168 hp., ratios to 10,000 to 1.

ABART GEAR and MACHINE CO.

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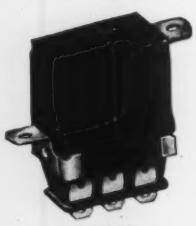
FOR PUBLIC ADDRESS, RADIO, and kindred fields, specify JONES 400 SERIES PLUGS AND SOCKETS of *proven* quality!

P-406-CCT



S-406-AB

Double Contact Area

Phosphor bronze knife-switch socket contacts engage both sides of flat plug contacts.

Socket contacts phosphor bronze, cadmium plated. Plug contacts hard brass, cadmium plated. Insulation molded bakelite. Plugs and sockets polarized. Steel caps with baked crackle enamel. 2, 4, 6, 8, 10, 12 contacts. Cap or panel mounting.

Information on complete line, in Jones Catalog 20: Electrical Connecting Devices, Plugs, Sockets, Terminal Strips. Write

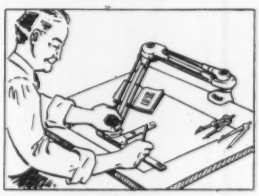
SEE NEW DEVELOPMENTS AT THE I. R. E. SHOW—BOOTHS 394-396

Jones HOWARD B. JONES DIVISION
CINCH MANUFACTURING CORPORATION
CHICAGO 24, ILLINOIS
SUBSIDIARY OF UNITED CARR FASTENER CORP

—ITEM 280—

when you know VEMCO there's a difference.....

Before



After

The VEMCO Drafting Machine combines all the working features of a T-square, protractor, and various scales and triangles

Speed and efficiency are lost in the shuffle, when you have to fuss and fumble over a drawing board that's cluttered up with equipment. The modern solution to that is the VEMCO Drafting Machine, which combines the working features of several pieces of drafting equipment. See your VEMCO dealer, and you'll see what a happy difference the VEMCO Drafting Machine can make in your work.

Write today for free illustrated brochure.

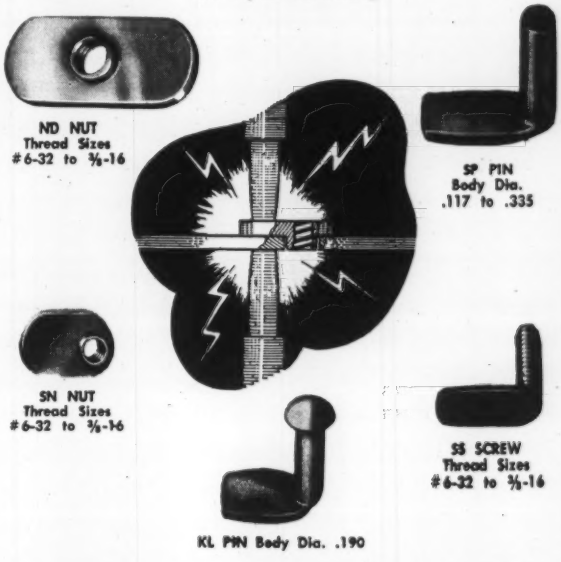
VEMCO

V. & E. Manufacturing Co.
Department AM
P.O. BOX 950-M • PASADENA, CALIFORNIA
Drafting Equipment of Quality

—ITEM 282—

OHIO STOCK PARTS

For Spot Welding



If you do spot welding specify that OHIO stock spotweld parts be attached at the same time for faster, trouble-free assembly.

Samples and information available upon request.

THE OHIO NUT AND BOLT COMPANY

Specialists in the Manufacture of Weld Fasteners and Adjusting Screws

38 FIRST AVENUE **BEREA, OHIO**

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FOR AUTOMATIC CIRCUIT-CONTROL

AIRMATIC VALVES

To meet the increasing demand for fully automatic or semi-automatic operations . . . eliminate the need for manual control. Airmatic Valves perform efficiently . . . maintain greater operating speeds. What's more, they are simple and compact in design—assure best arrangement.

A complete line of 2-way, 3-way and 4-way valves available for high-pressure or low-pressure installations.

Three-Way Valve **Solenoid Valves** **Cylinders**

Write today for complete details about Airmatic Products

Attractive O. E. M. and Quantity Discounts *Delivery from Stock —Immediate*

AIRMATIC VALVE INC.

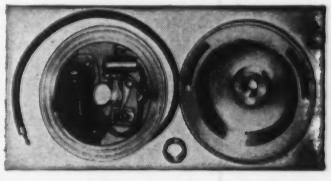
7317 Associate St. Cleveland, Ohio

—ITEM 284—

For Efficiency and Easy Starting it Will Pay You to Specify All 3 of these Fairbanks-Morse Products for your Small Gasoline Engines . . .

Fairbanks, Morse & Co. now offers three essential products for small engines—a flywheel magneto, rewind starter and a centrifugal clutch all designed to fit your engine.

FLYWHEEL MAGNETO

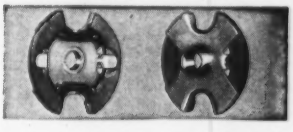


This magneto sets a new standard in both electrical and mechanical life—molded heavy-duty high tension coil—large, long-lasting breaker points—Alnico permanent magnets—easy starting and top efficiency is a certainty.

REWIND STARTER

50% lighter than other types of starters it is ruggedly constructed principally of die-cast aluminum alloy. Instead of meshing gears and pawls the starter mounts over and engages on a regular rope starter pulley. Only ¼ inch of pull is required for engagement. The nylon pull cord will last the lifetime of the equipment. Starting is unbelievably easy.

CENTRIFUGAL CLUTCH



Simple construction with few working parts—tool steel in vital parts. These clutches are resistant to heat and shock and are extremely long lived.

One of the toughest applications for a clutch is a chain saw.

Approximately 80% of all chain saws are equipped with this clutch. A wide range of engaging speeds is available—springs are adjusted to fit the specific application.

Get all the facts plus application assistance. Write Fairbanks, Morse & Co., Magneto Division, Beloit, Wisconsin.

FAIRBANKS-MORSE

a name worth remembering when you want the best

MOTORS • ZC ENGINE • MAGNETOS • STARTERS • CLUTCHES • PUMPS • DIESELS

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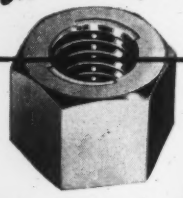
WE SELL
RELIABILITY
OF TORQUE

M·F
Uni-Torque®



AND ALWAYS
DELIVER
THROUGH
SIMPLICITY
OF DESIGN

NO EXCESS COST!
NO SLOTS
NO FIBRE
NO PLASTIC

Did you ever check your present lock nut for consistency of torque? It means *everything* in a lock nut! TESTS SHOW that due to more precise manufacturing techniques and *simplicity of design*, the M-F Uni-Torque delivers the most consistent torque.

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CHICAGO 40, ILLINOIS

"FEW OLDER IN EXPERIENCE . . . NONE YOUNGER IN FACILITIES AND DESIGN"

—ITEM 286—

ENGINEERS
AVAILABLE OR WANTED

WANTED: Mechanical Engineers and Mechanical Draftsmen. Growing company expanding Engineering Division. Opportunity for rapid advancement into management and development work on mechanical parking garages, aircraft hangars, industrial buildings, TV broadcast antenna towers. Liberal benefits including retirement. Moving expenses paid. Write: E. L. Smith, Dresser-Ideco Company, One of the Dresser Industries, 875 Michigan Avenue, Columbus 8, Ohio.

AVAILABLE: Electrical Engineer, technical graduate with BS degree and professional engineer on electric motors from 1/100 HP up. Over 20 years experience in motor applications and sales in Middle Atlantic States. Has had charge of territory doing over $1,000,000 business yearly. Would consider Manufacturer's Representative proposition. Address Box 891, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

MACHINE DESIGN ENGINEERS

You can be SURE

- of professional recognition
- of a successful financial future

AT THE ELECTRONIC TUBE DIVISION OF

Westinghouse

in Elmira, N. Y.

Yes . . . you can count on a friendly and creative atmosphere . . . world-important work . . . where everybody is on "your team", and your talents are tangibly rewarded. You and your family can also count on enjoying the "Elmira" way of life, a great combination of vacation-land facilities and all city advantages.

Openings for:
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Interviews in your area, or travel expenses paid for interviews in Elmira. Send resume:

R. M. Jarrett
WESTINGHOUSE ELECTRIC CORP.
Electronic Tube Div., P.O. Box 284, Elmira, N.Y.

—ITEM 287—

Thousands of dollars worth of protection for only pennies!

Threaded or Plain Plugs and Caps in a wide range of sizes.

Send for free samples and copies of Bulletins P-5312 and P-5203. Address Dept. 4P.

C-4

Here's a sure cure for costly shipping and handling damage

These low cost protective plastic plugs and caps are just what you need to give your products that vital "ounce of protection" against damaged threads, dirt and moisture. They're quickly and easily applied to any plain or threaded opening—and are available for immediate delivery in a wide range of sizes and styles.

S.S.WHITE PLASTICS DIVISION
10 East 40th St., N. Y. 16, N. Y.

S.S.White
PROTECTIVE PLASTIC CAPS and PLUGS

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"Directory of Materials"

18th Edition

the only one of its kind available anywhere

Reader Service Dept.
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$1.00 per Copy

ENGINEERS
Electronic Mechanical

There's room to...

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- Network Theory
- Systems Evaluations
- Microwave Technique
- UHF, VHF, or SHF Receivers
- Analog Computers
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- Digital Computers
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- Microwave Filters
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- Servomechanisms
- Subminiaturization
- Electro-Mechanical Design
- Small Mechanisms
- Quality Control and Test Engineers

More and more these days you hear top engineers talk about the many growth opportunities at Melpar. With an increasing number of significant electronic projects, an enlarged staff and facilities, Melpar provides many opportunities for professional growth and advancement. Our new laboratory is an engineer's dream come true; a building conceived by and constructed for the ENGINEER – 265,000 sq. ft. of complete engineering facilities.

We are located in Fairfax County of northern Virginia where housing is reasonable and plentiful—whether you desire a private home or an apartment. Although we are in a truly suburban atmosphere, we are only 10 miles from the nation's capital with all its recreational and social advantages. Here you and your family can grow in an environment to match your professional growth.

Send resume to Technical Personnel Representative,

melpar, inc.
A subsidiary of the Westinghouse Air Brake Co.
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11 Galen Street, Watertown, Mass. • 99 First St., Cambridge, Mass.

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are needed for

TELEVISION & RADIO RECEIVER chassis design incorporating printed circuit boards, formed, stamped, and molded parts, and provision for mechanical production techniques.

SPECIAL MECHANISM DESIGN for TV receivers, including control knob linkages, simplified switching techniques, and automatic tuning devices.

Send resume to: E. S. Winlund
Television Receiver Dept.

GENERAL ELECTRIC

Electronics Park, Syracuse, New York

—ITEM 290—

to help you solve your spring design problems

"MECHANICAL SPRINGS"

by A. M. Wahl

THOROUGH DISCUSSION OF FUNDAMENTAL PRINCIPLES . . . PRACTICAL FORMULAS FOR DESIGN . . . AUTHORITATIVE INFORMATION ON SPRING APPLICATIONS . . . IN 435 PAGES FULLY ILLUSTRATED WITH DETAILED DRAWINGS.

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It contains the kind of information that enables preliminary calculations to be made on the design of all types of springs: helical, disk, Belleville, flat, leaf, torsion, spiral and volute.

And no matter what your problem . . . working stress . . . fatigue . . . buckling . . . or just plain maximum efficiency, you will find that "MECHANICAL SPRINGS" can reduce the "guesswork" as well as save you time and materials.

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COMPANY _____

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CITY _____ ZONE ____ STATE _____

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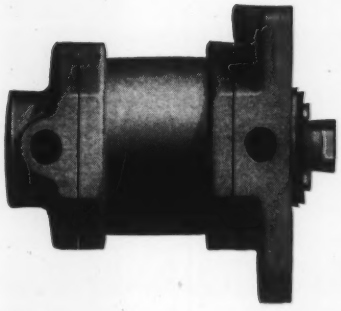
Quick Delivery?

YES!

If you're in a tight spot and need standard models, Rivett can ship in two days.



Low Price?

YES!

You'll make the best deal with Rivett. Large volume production makes prices competitive!

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YES!

This is the most important reason for choosing Rivett! After a cylinder is installed, delivery and price are soon forgotten—but not the cylinder's productivity! It is then that a poor cylinder reveals its really high cost. For its faulty construction can result in operational failure—with a breakdown in production.

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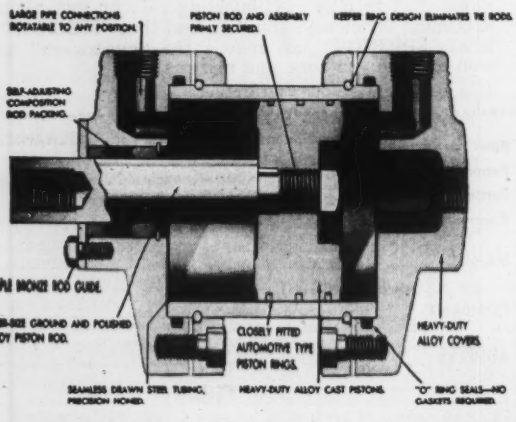
See Rivett Cylinders at Booth 324, A. S. T. E. Show, Chicago, March 19-23.

THE BETTER YOU KNOW HYDRAULICS, THE BETTER YOU LIKE RIVETT!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SELF-ADJUSTING COMPOSITION ROD PACKING.
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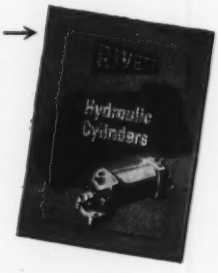
Dept. MD-3 Brighton 35, Boston, Mass.



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Member—National Fluid Power Association

RIVETT

furnishes a complete power package

AIR AND HYDRAULIC — VALVES, CYLINDERS, POWER UNITS

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BPA NBP

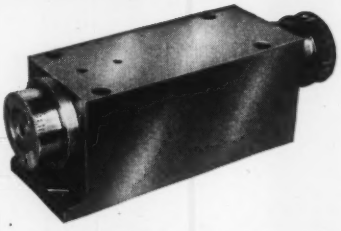
POPE PRECISION SPINDLES

Of Special Interest and Value To All **TOOL ENGINEERS**

See these Spindles at Federal Machinery Sales Co., Booth No. 392, ASTE Show

EXHIBIT A

POPE SUPER-PRECISION, HEAVY DUTY BORING SPINDLES for boring holes round within millionths of an inch. Available in both belt driven and motorized units to meet a wide range of speeds and horsepower. Send us your specifications for quotations.



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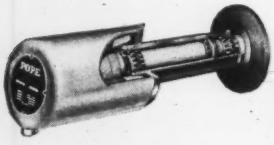
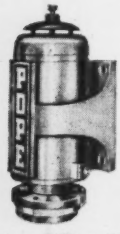


POPE 1 HP, TOTALLY ENCLOSED 3600 RPM MOTORIZED, CARTRIDGE TYPE PRECISION SPINDLES with double row cylindrical roller bearings and separate thrust bearings for no endwise movement of the shaft.

EXHIBIT C



POPE HEAVY DUTY ¾ to 100 HP DIRECT MOTORIZED SPINDLES for Horizontal or Vertical Skin Milling, Grinding, Milling, Boring and Other Operations.

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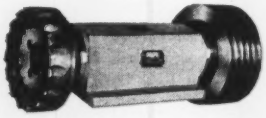

POPE HEAVY DUTY VEE-BELT DRIVEN, PRECISION MILLING SPINDLES, and Wheel Heads, ½ to 50 HP.

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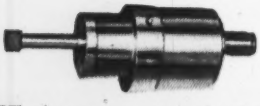

POPE INTERNAL GRINDING SPINDLES for Bryant, Excello, Heald and Landis Grinders.

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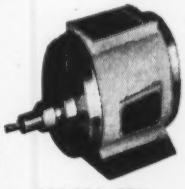

POPE SUPER-PRECISION HIGH FREQUENCY HEAVY DUTY GRINDING AND MILLING SPINDLES for speeds up to 100,000 RPM.

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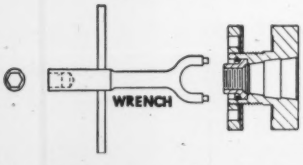
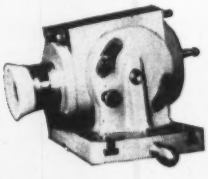


NEW **POPE** QUICK, SELF-REMOVING WHEEL HOLDER for surface grinders and tool and cutter grinders—eliminates the necessity of a wheel puller. Write for quotations.

EXHIBIT H



POPE SUPER-PRECISION MOTORIZED TOOL AND CUTTER GRINDER SPINDLES with clearance Angle Swiveling Heads for Angular Adjustment in A Vertical Plane.

WRITE FOR COMPLETE SPECIFICATIONS, PRICE AND DELIVERY

No. 108

Specify **POPE** PRECISION SPINDLES

POPE MACHINERY CORPORATION
Established 1920
261 RIVER STREET · HAVERHILL, MASSACHUSETTS

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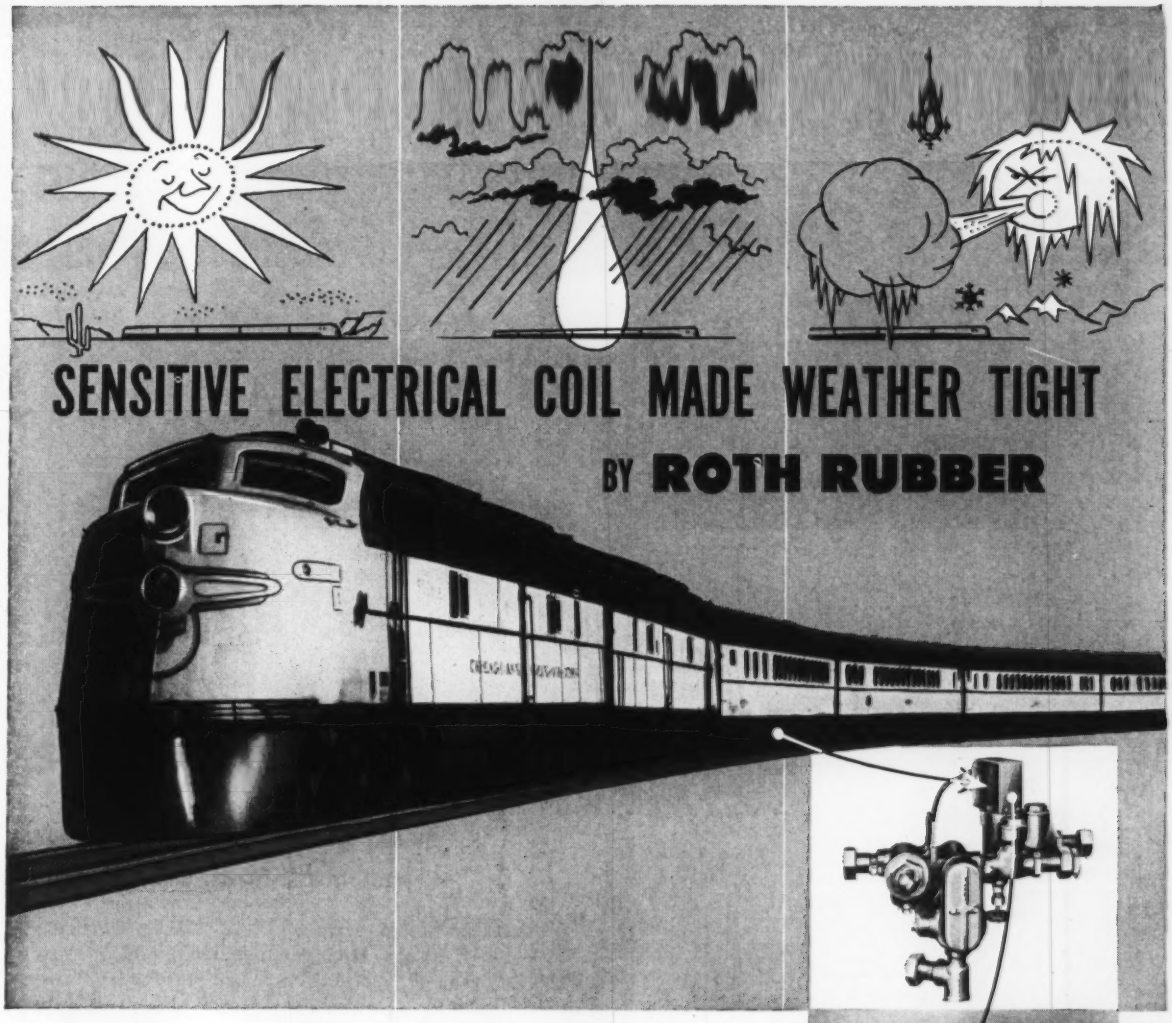
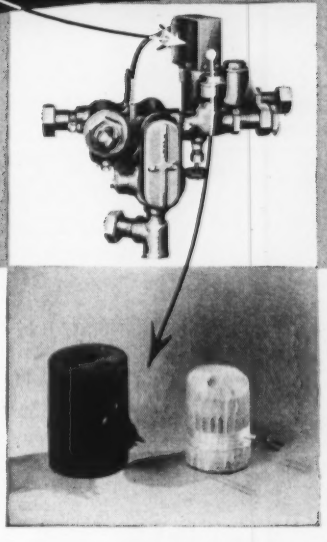


SENSITIVE ELECTRICAL COIL MADE WEATHER TIGHT BY ROTH RUBBER



Moisture Tight Molded Rubber Coil Cover Helps Insure Passenger Comfort in Toughest Weather

Problem: To keep driving rain, swirling snow and flying dirt from shorting out the all important electric coil of Vapor Heating Corporation's train heating system. As these heating systems are used by railroads all over the world, every type of weather condition had to be taken into consideration.

Solution: ROTH RUBBER's answer was to develop a method of molding the coil into a moisture tight cover of specially compounded heat and weather resistant rubber developed by ROTH's technicians.

ROTH RUBBER can make your molded rubber products.

If you have a product or production problem, let ROTH help you out. 33 years of experience in compounding rubber and precision molding know-how means a better product at a competitive price.

FREE SAMPLE

SEND FOR SAMPLE AND INFORMATION ON AMAZING NEW SOFT RUBBER...

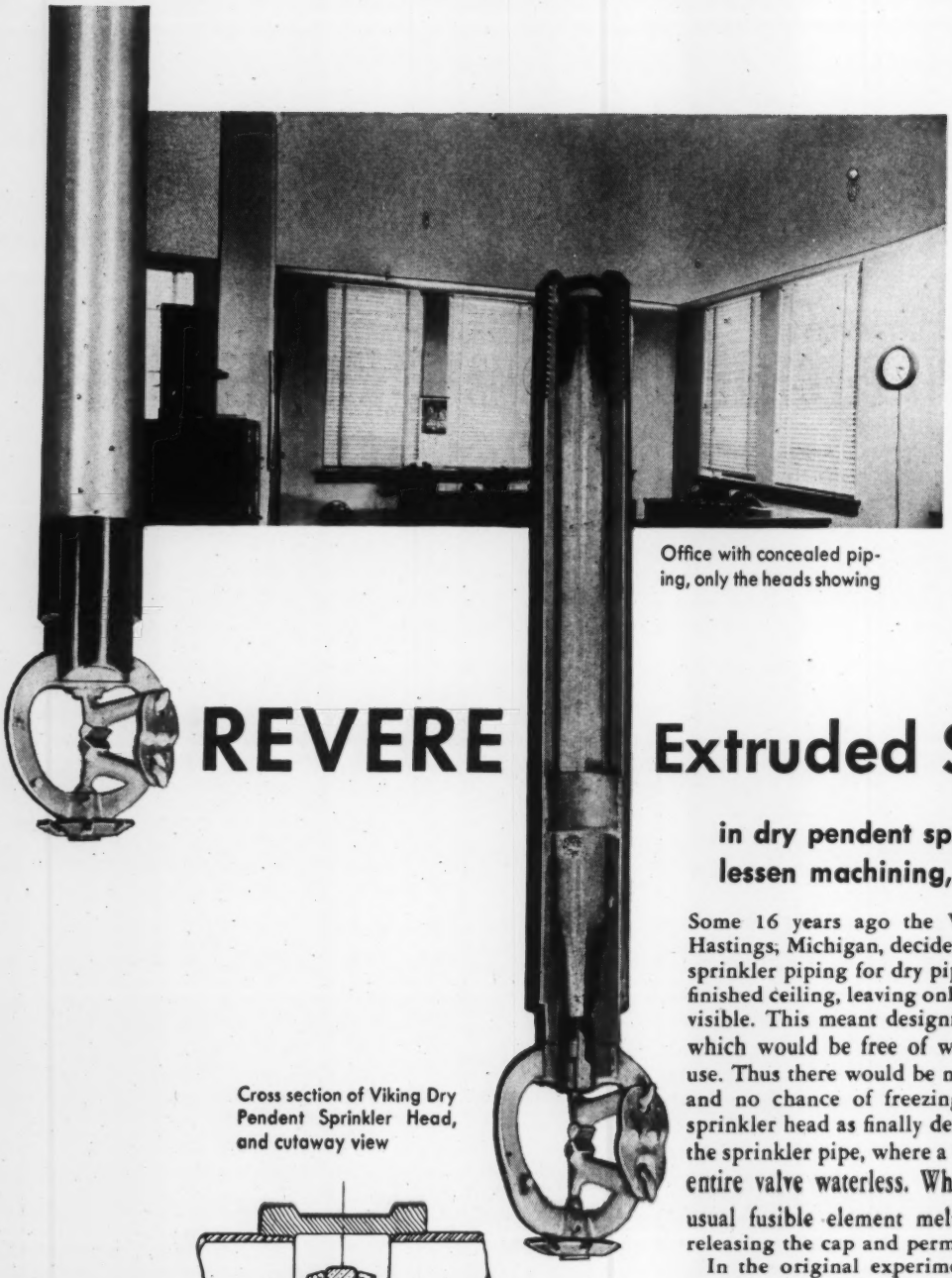
A new, non-porous rubber development by ROTH offers excellent cushioning and sound absorbing possibilities...makes a soft, pliable seal for many gases and liquids. Can be molded to suit your requirements. Send now for sample and information.

ROTH RUBBER COMPANY

Dept. MD-10 1860 S. 54th Avenue, Chicago 50

—ITEM 293—

For More Information Circle Item Number on Yellow Card—page 19



Office with concealed piping, only the heads showing

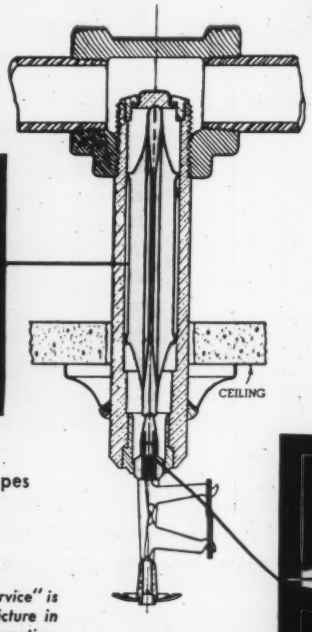
REVERE Extruded Shapes

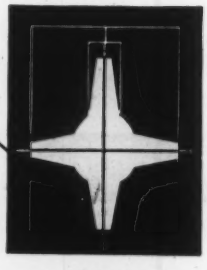
in dry pendent sprinkler heads lessen machining, save money

Some 16 years ago the Viking Corporation, Hastings, Michigan, decided to find a way to put sprinkler piping for dry pipe systems above the finished ceiling, leaving only the sprinkler heads visible. This meant designing a sprinkler head which would be free of water except when in use. Thus there would be no drainage problem, and no chance of freezing. The dry pendent sprinkler head as finally developed extends into the sprinkler pipe, where a bronze cap keeps the entire valve waterless. When a fire occurs the usual fusible element melts, two struts drop, releasing the cap and permitting water to flow.

In the original experimental work, the two struts were machined out of solid brass bar. This took time and involved the generation of a considerable amount of scrap, since each strut has four deep fins. Once the idea had proved itself, Viking came to Revere for extruded shapes, in order to save both machining and metal. So much time has elapsed since the original machining of the bar that comparative cost figures would be meaningless, but it is evident to Viking, and to everybody familiar with extruded shapes, that the saving is substantial.

Cross section of Viking Dry Pendent Sprinkler Head, and cutaway view





Outline of the two shapes supplied by Revere

"The Revere Four-Way Service" is a 16mm. sound motion picture in color, educational and informative. If you haven't seen it, write nearest Revere Sales Office.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, N. Y.

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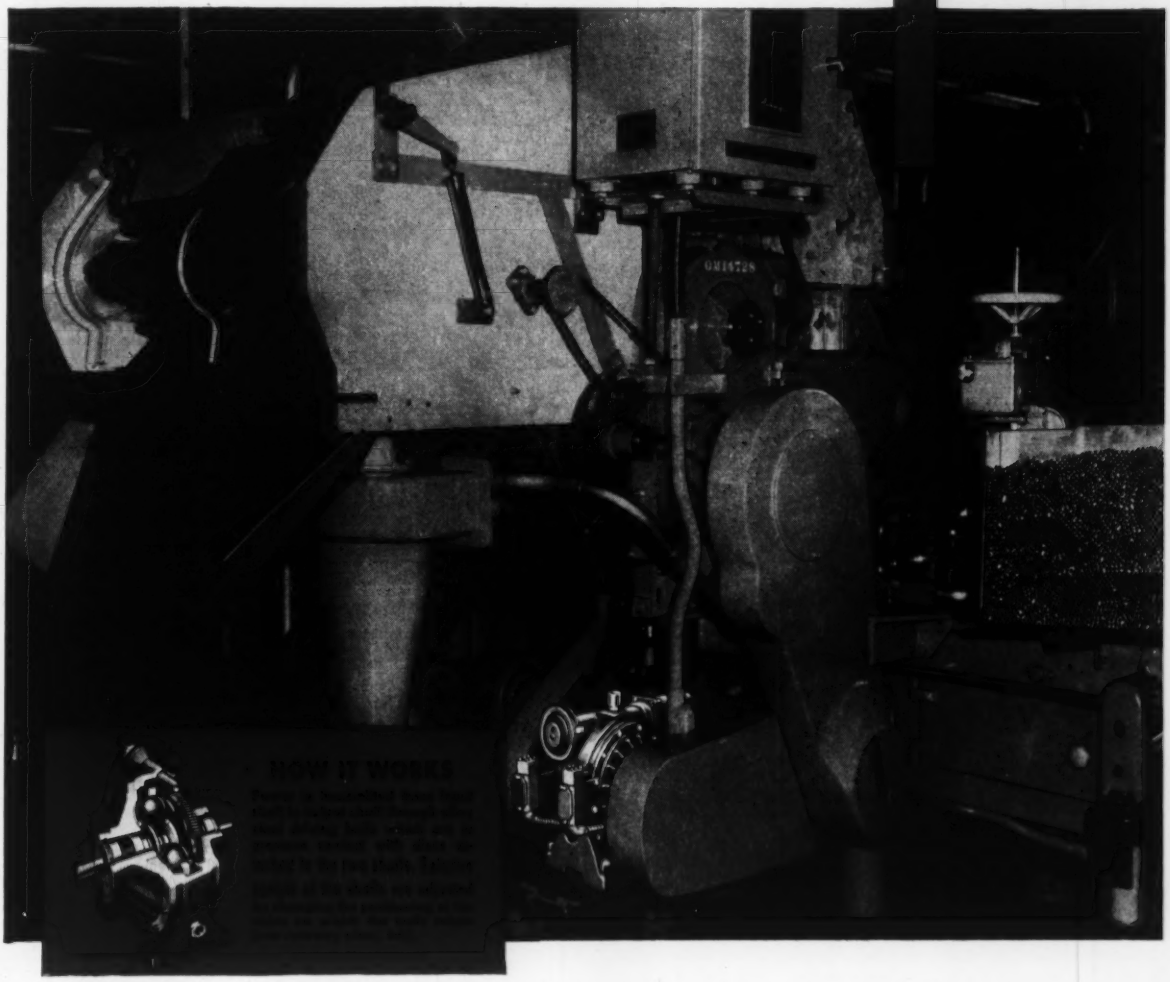
Mills: Baltimore, Md.; Brooklyn, N. Y.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside Calif.; New Bedford, Mass.; Newport, Ark.; Rome, N. Y. Sales Offices in Principal Cities, Distributors Everywhere.

—ITEM 294—

AccuRay electronic brain gets muscle power from Cleveland Speed Variator

The electronic control mechanism of this cigarette machine, known as the AccuRay cigarette gage controller, built by Industrial Nucleonics Corp., Columbus, Ohio, employs Cleveland Speed Variator size 4K4, driven at 1200 rpm input.



NATIONALLY famous for checking and controlling the making of Chesterfield cigarettes, AccuRay depends on a Cleveland Speed Variator for the delicate job of adjusting the tobacco feed rate in response to impulses from the gaging mechanism.

Being infinitely variable, the Cleveland Speed Variator gives stepless speeds over a full 9:1 range—from ⅓ to 3 times input speed. Output speed on this application is adjusted automatically by a regulating motor mounted on the Variator—but could be regulated manually or by remote controls of other types.

Available in eighteen standard types and sizes, the Cleveland Speed Variator offers these major advantages: 1. An extremely compact unit with input and output shafts in line and rotating in the same direction; 2. Almost any input speed up to 1800 rpm can be used—either clockwise or counterclockwise rotation; 3. Rated for constant horsepower output over a 9:1 range, or for constant output torque with a 6:1 range; 4. Infinitely variable over the entire speed range; 5. Rapid response to speed change, precise adjustment, and accurate maintenance of speed settings; 6. Long life and minimum maintenance due to absence of belts or complicated linkages; 7. Ample bearing support for overhung pulleys on either input or output shafts.

Write for Bulletin K-200 for detailed description with photographs, sectional drawings, rating tables and specifications.

THE CLEVELAND WORM AND GEAR COMPANY

Speed Variator Division, 3287 East 80th Street, Cleveland 4, Ohio

Sales Representatives in all major industrial markets • In Canada—Peacock Brothers Limited

—ITEM 152—

For More Information Circle Item Number on Yellow Card—page 19